ANALYSES OF THE WORLD PROCESSED ORANGE INDUSTRY

By

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} Orange Buds by Mail from Florida

A lesser proof than old Voltaire's, yet greater,
Proof of this present time, and thee, thy broad expanse, America,
To my plain Northern hut, in outside clouds and snow,
Brought safely for a thousand miles o'er land and tide,
Some three days since on their own soil live-sprouting,
Now here their sweetness through my room unfolding,
A bunch of orange buds by mail from Florida.

Walt Whitman
Leaves of Grass
1855
[BOOK XXXIV. SANDS AT SEVENTY]

This work is dedicated to the memory of Mr. Carl Fischer, the founder of Citrosuco, an immigrant who believed in Brazil and its promising future, and let me become a member of the world citrus family.

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ANALYSES OF THE WORLD PROCESSED ORANGE INDUSTRY

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The processed orange industries of Florida, U.S., and Sao Paulo, Brazil, produce more than 85 percent of the orange juice consumed in the world. In such enormous industries, it can be expected that there is a myriad of challenges facing the orange processed market. Hence, this dissertation studies three issues and for each issue it uses a different methodological approach.

The first issue relates to governance structures of citrus operations in Florida and Sao Paulo. While the orange juice produced in both regions are near perfect substitutes, the citrus processing industries in Sao Paulo and Florida differ. Such contrast is analyzed with insights from the New Institutional Economics, and findings show that Sao Paulo's partial backward vertical integration is not a superior model to Florida's separate ownership of orange growing and processing, nor vice versa. Rather, the processing industry in each country has optimally adapted to the institutional environment that exists in each region.

The second issue refers to the impact of citrus variegated chlorosis (CVC) in the Brazilian citrus industry. Unlike the United States, Brazil is the only major orange producing country in the world affected by this bacterial disease present in over one-third of the tree inventory. So far there is no cure for CVC and Brazil has lived with it by adopting relatively costly measures of control. The economic impact of CVC is analyzed in the context of a spatial equilibrium model of the world orange juice market. Findings show an annual impact, at least for the first decade of the 21st century, of US$ 286 million to US$ 322 million and about 60 million boxes equivalent of lost production of Brazilian orange juice.

The last study discusses duty drawback as a mechanism to foster U.S. orange juice exports. Under the current tariff rates, the duty drawback subsidy has helped the U.S. to compete with Brazil in orange juice exports. Through an econometric model, the effect of changes in the duty drawback law is measured at different levels of subsidy cuts, and findings show that, without changing the tariffs, U.S. orange juice exports would decrease by 21.8 million SSE gallons annually if duty drawback were removed integrally.

CHAPTER 1
INTRODUCTION

In the United States, almost two-thirds of the total quantity of fruit utilized for processing is to make fruit juice, and oranges along with grapefruit account for over 85 percent of all the fruit used for producing juice (Economic Research Service/U.S. Department of Agriculture [ERS/USDA] 2002). Florida is by far the largest U.S. citrus producing and processing state.

The Florida citrus industry is estimated to have a US$ 9.13 billion economic impact to the state and to employ nearly 90,000 people in the 1999-2000 season (Hodges et al. 2001).

In Brazil, citrus is concentrated in the state of Sao Paulo, which represents nearly 85 percent of Brazilian production and virtually all the Brazilian FCOJ (frozen concentrated orange juice) exports (The Brazilian Association of Citrus Exporters [Abecitrus] 2003).

The Sao Paulo citrus industry in Brazil is considered to employ 400,000 people and to export US$ 1.3 billion in juice, mostly FCOJ, but also fresh orange, pulp pellets and essential oils in 1999 (Neves et al. 2000).

While oranges are produced in many countries with tropical or subtropical climates, the processed orange industries of Florida and Sao Paulo dominate the world market for orange juice (OJ). These two states produce more than 85 percent of the OJ consumed in the world (Food and Agriculture Organization [FAO] 2003).

In such a large and complex industry, it can be expected that there are numerous challenges facing the orange processed market. Among those, three issues are presented and analyzed in this dissertation.

Firstly, while the final products produced in both regions are near perfect substitutes, there are major differences in the governance structure of the two industries. The citrus processing industry in Sao Paulo has high degree of partial backward vertical integration, whereas the one found in Florida does not. Governance structure or institutional arrangement is understood to be "the contractual relation ... between economic entities that defines the way in which they cooperate and/or compete" (Williamson 1996, p. 378). Partial backward vertical integration means processors own grove operations to partly supply their plants' crushing capacities.

Despite the fact that the U.S. and Brazil have been strong competitors and present marked differences in their processed orange industries' governance structures, there have been investments in Florida by Sao Paulo-based orange processors that need to be explained under the light of economic theory.

Thus, in the first paper, an analysis of the governance structure of the world processed orange industry is presented, with an overview of the world OJ market, and a review of recent events in Florida and Sao Paulo that includes a comparison of governance structures in these regions for the 1989-90 and 2001-02 seasons. The contrast in the governance structure prevalent in Florida versus the one observed in Sao Paulo is noted and insights from the New Institutional Economics are used to help explain why dichotomous governance structures have evolved in the two major OJ producing regions.

Secondly, unlike Florida, Sao Paulo is the only major orange producing region in the world affected by CVC (citrus variegated chlorosis), a bacterial disease present in over one-third of the orange trees in Brazil (The Fund for Citrus Plant Protection [Fundecitrus] 2003). Much research and investment have been focused on sequencing and analyzing the causal bacterium of CVC, *Xylella fastidiosa* (Chang et al. 1993), in Brazil in an attempt to find a cure for the disease. So far, Sao Paulo has lived with CVC by adopting the following measures of control: pruning of affected branches, spraying of vectors and production of seedlings in greenhouses, all of which have likely increased the cost of production.

The economic importance of CVC is incontestable: in 2000, losses were estimated at US$ 250 million (Fundecitrus 2003). Across all sweet orange varieties grown in Brazil, production losses are found in plants with severe symptoms, such as reduction in the size and weight of fruits. It has been estimated that the production decrease in highly affected trees is about 75 percent when compared to healthy ones (Ayres 2000). Therefore, on the supply side, CVC represents a prominent threat to the leading role that Brazil plays in the world OJ market.

The second paper of this dissertation analyzes the aforementioned threat in the context of a mathematical programming model of the world OJ market (McClain 1989). Two scenarios are analyzed via a spatial equilibrium model on the impact of CVC incidence, with and without the disease, focusing not only on the modeling but also on the issue and its results and implications.

Thirdly, although the United States is a net importer of OJ, a notable amount for blending, the U.S. also exports OJ, some of which is eligible for duty drawback. Duty

drawback is a refund of duties (e.g., tariffs) or internal revenue taxes. The U.S. government has offered drawback provisions to foster the export of various U.S. agricultural commodities since the Tariff Act of 1789 (Hill 1893). The intention of drawback is to encourage U.S. commerce and manufacturing.

Most U.S. imports of OJ are subject to a tariff, which is a fixed dollar amount collected/assessed per unit of product (excise tax). For 2003, the most favored nation (MFN) tariff rates for FCOJ and not-from-concentrate OJ (NFC) are US$ 0.2972 per single strength equivalent (SSE) gallon and US$ 0.1704/SSE gallon, respectively. The MFN tariff rates have declined by 15 percent since 1994 in compliance with Uruguay Round of the General Agreement on Trade and Tariffs (GATT). No further tariff rate declines are scheduled, but with the trend towards trade liberalization at the World Trade Organization (Doha Round), including special trade agreements among blocks of countries such as the Free Trade Area of the Americas (FTAA), uncertainty exists with regard to what future tariff rates may be.

Brazil, classified as a MFN, is the dominant supplier of imported OJ to the U.S. market and has "a cost advantage in delivering bulk FCOJ to both the U.S. and the European markets" (Muraro and Spreen 2003, p. 3). Drawback has enabled the U.S. to cover such cost differential and compete in some export markets. If the duty drawback subsidy is removed under the current tariff rates, U.S. exports would be expected to decrease, since Florida OJ producers would no longer have the negative tax that they need to foster their exports.

Learning how much U.S. OJ exports are affected by changes in duty drawback, which is tied to the MFN tariff schedule, contributes to a better understanding of the

relevance of duty drawback as a strategic marketing policy mechanism to foster U.S. OJ exports under current tariffs. Therefore, the third paper provides estimates of the impact of duty drawback on the U.S. OJ export demand indirectly via a single equation econometric model in which exports in SSE gallons are regressed against the following relevant explanatory variables: time trend, U.S. OJ price, Rotterdam OJ price, European exchange rate, and quarterly dummies to remove seasonality. Additionally, a simulation is provided in order to measure the effect of changes in the duty drawback law at different levels of subsidy cuts.

In the following chapters, the three papers are presented and an overall conclusion chapter is provided at the end of this dissertation.

CHAPTER 2
UNDERSTANDING DIFFERENT GOVERNANCE STRUCTURES: THE CASES OF THE PROCESSED ORANGE INDUSTRIES IN FLORIDA, U.S., AND SAO PAULO, BRAZIL

Introduction

"The attributes of human actors have massive ramifications for economic organization; economic organization also has a life of its own; and economic organization is also shaped by the institutional environment within which it is embedded" (Williamson 1998, p. 34).

While oranges are produced in many countries with tropical or subtropical climates, the processed orange industries of Florida, United States, and Sao Paulo, Brazil, dominate the world market for orange juice. These two states produce more than 80 percent of the orange juice consumed in the world. While the final products produced in both regions are near perfect substitutes, there are major differences in the governance structure of the two industries. Most of the citrus processing industry in Sao Paulo is partly backward vertically integrated, while the one found in Florida is not.

Recently, there have been many changes in the governance structure of the processed orange industry, especially in Florida. Many processing plants have new ownership within the last 10 years and there has been consolidation in the industry. Another interesting trend that has evolved is the increasing separation of orange production from orange processing. In 1990, families or companies that were major orange growers processed approximately 50 percent of Florida orange juice production

and owned 12 of the 29 plants operating in Florida. By 2001, only two of 18 plants were owned by orange growing enterprises, which processed approximately 12 percent of Florida's production.

The trend away from backward vertical integration (BVI) observed in Florida diverges from traditional economic wisdom concerning why firms integrate (e.g., oranges are highly perishable and the coordination among procurement, harvest and processing is not costless because this coordination is complicated and must deal with random events such as weather). In contrast, there still is a high degree of vertical integration between growing and processing in Sao Paulo just as there was in the early 1990s.

Theory suggests that the Florida citrus processing industry would have strong incentives to backward integrate and own orange groves. However, during the past 12 years, the exact opposite has happened, with a significant trend towards separate ownership of orange groves and orange processing facilities. How can this apparent disconnect between theory and empirical observation be explained?

Ronald Coase, in his opening address to the 1999 conference of the International Society for New Institutional Economics, sets the stage and provides the methodological tools with which agricultural economists can do empirical work on problems earlier considered non-researchable within the boundaries of mainstream economics. As he stated, "if we are to understand the effect of different institutional arrangements on the working of the economic system, the obvious way to do this is to compare what happens in different countries with differing arrangements" (Coase 1999).

In this paper, an analysis of the governance structure between processing and growing within the world processed orange industry is presented. In the first section,

theories of New Institutional Economics on BVI are reviewed. The second section provides the case (i.e., an overview of the world orange juice market), a review of recent events in Florida and presents the governance structure in Florida for the 1989-90 and 2001-02 seasons, and provides similar information for Sao Paulo, Brazil. In the third section, the problem statement and the hypotheses to be tested are given. The fourth section describes the methods utilized. In the fifth section, an analysis of the contrast in the governance structure prevalent in Florida versus that observed in Sao Paulo is noted and insights from New Institutional Economics are used to help explain why dichotomous governance structures have evolved in the two major orange juice producing regions. The last section of the paper contains a synthesis of results and concluding remarks.

It is not the aim of this paper to discuss firm scale limits, that is, up to what extent a firm should be vertically integrated. The paper is actually concerned with analyzing the appropriateness and efficacy of governance structure choices.

Vertical Integration

In this section, a literature review on vertical integration with theoretical insights from the New Institutional Economics is provided, and some concepts are operationalized and illustrated within the empirical cases of this study.

Vertical Integration and Transaction Costs

Williamson (1985, p. 85-6) states that "vertical integration can and sometimes does serve a variety of [strategic] economic purposes, [with] economizing on transaction costs" the ultimate goal. Transaction costs are understood as "the costs of running the economic system," better defined as "the ex ante costs of drafting, negotiating, and

safeguarding an agreement and, more especially, the ex post costs of maladaptation and adjustment that arise when contract execution is misaligned as a result of gaps, errors, omissions, and unanticipated disturbances" (Williamson 1996, p. 379).

According to Williamson (1985), there are three types of integration: backward vertical into inputs, lateral into components, and forward vertical into distribution, that when combined together are called comprehensive integration. Firms that are partly vertically integrated (i.e., that for instance simultaneously procure raw product from both internal and market sources) are said to be partly integrated, such as several orange juice processors in Florida in the late 1980s and in Sao Paulo, Brazil, over the last 12 years. Williamson (1985, p. 96) points out "where firms are observed both to make and to buy an identical good or service, the internal technology will be characterized by greater asset specificity than will the external technology, ceteris paribus." Williamson (1996, p. 377) defines asset specificity as being "a specialized investment that cannot be redeployed to alternative uses or by alternative users except at a loss of productive value."

"The magnitude of the hazards depends on the attributes of the assets and on the characteristics of the contracting relation" (Williamson 1985, p. 89). Although frozen concentrated orange juice (FCOJ) is considered a commodity, processors look for quasi-BVI and long-term contracts in order to comply with their buyer's specifications regarding quantity, quality, and deadline for delivery (e.g., temporal specificity). Their intent is to meet their clients' needs with a guaranteed supply. Accordingly, the higher the required attributes of the assets and the less stable the contract, the more hazardous the transaction, thus the more likely the existence of quasi-market and internal governance structures.

> The principal factor to which transaction cost economics appears to explain vertical integration is asset specificity. Without it, market contracting between successive production stages ordinarily has good economizing properties. Not only can production economies be realized by an outside supplier who aggregates orders, but the governance costs of market procurement are negligible since neither party has a transaction-specific interest in the continuity of the trade. As asset specificity increases, however, the balance shifts in favor of internal organization. (Williamson 1985, p. 90)

However "the high-powered incentives of markets are unavoidably compromised...when a transaction is placed under unified ownership" (Williamson 1985, p. 395).

Even though both Sao Paulo and Florida produce FCOJ of similar quality, Sao Paulo-based processed orange firms have adopted different governance structures compared to Florida. The two industries operate in different institutional environments (i.e., rules of the economic game) and hence will likely find different preferred levels of asset specificity. Different institutional environments have different relative prices, opportunity costs, incentives, risks, uncertainties, etc. Thus, the governance structure that minimizes transaction costs in one institutional environment may not necessarily also minimize transaction costs in a different institutional environment.

Processors both in Sao Paulo and in Florida are constrained neither legally nor even geographically to procure oranges in the local market. Hence, processors have a choice: purchase all of their oranges, produce all of their oranges themselves, or some hybrid combination of these options. Instead of seeing firms totally vertically integrated, what is noticed is the presence of forms of quasi-integration. So what are the reasons that would make those firms choose different governance structures?

According to Arrow (1975, p. 182), “the vertically integrated firm might be less efficient than the sum of the firms” because “a vertically integrated firm will not sell the raw material, though it may buy additional amounts on the open market,” which is a condition to restrict the incentive for vertical integration. “Preliminary analysis suggests that this restriction will lead to extremes; either there will be no vertical integration at all, or … it will proceed to the limit.” There is no record of any processor in the citrus industry being entirely backward vertically integrated. Moreover, depending on market conditions, in Sao Paulo for instance, orange processors sell raw material to other processors and on the fresh market, too. They buy oranges mostly through contracts and also spot, a market in which commodities are delivered immediately for cash.

Every firm is faced with the following decision: to make (m) or buy (b) a good? "Choice between firm and market thus turns entirely on governance cost differences" (Williamson 1985, p. 90); i.e., in order to backward vertically integrate, it is necessary that the difference between the marginal benefit obtained from an additional fresh fruit equivalent unit of FCOJ produced with purchased oranges (MBb), the marginal cost of procuring (MCb) and the marginal governance cost of processing one more unit of purchased oranges (MGCb) be offset by the difference between the marginal benefit obtained from an additional fresh fruit equivalent unit of FCOJ produced from its own orange groves (MBm), the marginal cost of procuring (MCm) and the marginal governance cost of processing one more unit of its own oranges (MGCm). MGCb would be negligible if neither party has a transaction-specific interest in the continuity of the trade, which is not the case, chiefly from the processor’s perspective.

The relationship implying BVI described above would then be represented by the equation (MBm – MCm – MGCm) – (MBb – MCb – MGCb) > 0 $\Rightarrow$ B.V.I.

The benefits from BVI in citrus processing are clear. The processor may insure a stable supply of raw product, and it can more easily facilitate the scheduling of harvest and processing. With a perishable product such as oranges, minimization of the time between harvest and processing increases juice yield and thereby operational efficiency.

The reasons to backward vertically integrate into raw materials may be many, but there are three main explanatory driving factors according to Williamson (1985, p. 118): to economize in transaction costs, for strategic purposes, or simply by mistake, and Williamson (1985, p. 119) stresses that "mistaken integration may not quickly be undone."

Chandler, cited by Williamson (1985, p. 120), investigated BVI "into the buying and storage of agricultural products … undertaken by American Tobacco and by Campbell Soup and Heinz." The study reports that the reason for backward integration is to assure a "steady supply" of tobacco, vegetables, and other perishables, although "more detail would be needed to assess the nature of the market breakdown (if such there was)."

Vertical Integration and Information

Arrow (1975, p. 173) considers BVI as a means of solving the problem of "uncertainty in the supply of the upstream good and the consequent need for information by downstream firms." Another reason for BVI is provided by Tucker and Wilder (1977, p. 82), who state that "backward vertical integration improves the ability of the downstream firm to forecast the input price and hence to improve the input-mix decision [the capital level]."

Arrow continues by affirming that processors use futures prices to make correct investment decisions. However, due to severe penalties for failure to deliver futures contracts, citrus growers would make them for the minimum output they are absolutely assured of honoring. There will remain an active spot market whose price will not be known in advance with certainty, given that the futures price will not signal the same information as if processors were acquiring all the groves owned by independent growers. Thus, the acquisition of successively more groves would represent an increase in information.

Vertical Integration and Concentration

Another major difference between the processing industries of Florida and Sao Paulo is the degree of concentration. The five largest firms in Sao Paulo account for over 80 percent of processed orange exports. This figure is used as a proxy to measure the level of concentration in Sao Paulo. In Florida, this figure is not publicly available, but private sources suggest that the five largest processors in Florida account for approximately 50 percent of processed orange production.

Azevedo (1996) argues that the pattern of governance of the processed orange industry in Sao Paulo is a result of not only the need for quality and the gains obtained from transaction costs minimization, but also the use of bargaining as a tool to impose asymmetry on the process of fruit procurement. Therefore, the degree of BVI seen among citrus processors in Brazil has helped them lower both their fruit procurement costs and the associated transaction costs.

In other words, the fact that there are a relatively few number of processors in Sao Paulo gives them leverage in the negotiation process with growers. Based upon figures

presented by Missiaen (2000), oranges from groves owned by the five largest processors account for 20 percent of processed orange utilization in Sao Paulo. A few large growers account for another 10 percent. Approximately 1,500 families account for another 40 percent of processed orange production. It is likely that most of the growers in this group have long-term contracts with processors. The remaining fruit is purchased from a group of 16,000 farms mostly on a year-to-year basis. This group is treated as residual suppliers of fruit because, in 1999, an estimated 40 million boxes of fruit were abandoned because it would not be purchased by processors and could not be sold in the domestic market. But in years of crop shortage due to severe drought for instance, this situation changes dramatically.

Thus, one could argue that Brazilian processors have developed a system in which most of their raw product needs can be met from their own production and supplied through long-term contracts. In years with lower yields, supplementary product can be acquired from other growers through increased prices. In years with high yields, these residual suppliers are discouraged through low offer prices and are forced to sell their fruit to the domestic market. While this practice may be used to a lesser degree in Florida, active enforcement of antitrust laws and strong lobbying from grower organizations discourage processors to collectively not accept fruit.

Another aspect to be observed with respect to vertical integration and concentration is, as Bolton and Whinston (1993, p. 123) argue, that "integration can reduce the competitiveness of non-integrated firms," because of "the negative externality that vertical integration imposes on the non-integrated downstream firm" and also on the market (Arrow 1975), which seems to be a case of vertically integrated firms imposing

market power. In years of crop shortage in Brazil, fruit procurement is very contentious, therefore driving fruit prices up so that those processors who are not well backward vertically integrated are forced to shut down since the margin between juice and fruit becomes very narrow, which turns their business unprofitable.

Overview of the World Processed Orange Market

The states of Florida, U.S., and Sao Paulo, Brazil, together produce approximately 85 percent of the world's orange juice. Mexico and Cuba in the Western Hemisphere and Italy, Spain, and Greece in Europe also produce orange juice for export. World production of orange juice by country is shown in Table 2-1.

Table 2-1. Processed Orange Production by Country, 1998[a].

Country	Production (1,000 MT)
Brazil	13,464
United States	10,213
Italy	940
Mexico	700
Spain	664
Cuba	345
Greece	310
South Africa	228
Argentina	196
Australia	192
Israel	142
Others	495
Total	27,889

Source: Food and Agriculture Organization (FAO).
[a] Figures presented are in fresh fruit equivalent.

The United States is the largest processed orange consuming country in the world. Canada is also a large market despite its relatively small population; Canada's per capita consumption rivals that found in the United States. The other countries of the Western Hemisphere, however, do not have significant consumption of commercially produced orange juice. Consumers in these countries still buy oranges in fresh form and produce

orange juice at home. Thus, nearly all of Brazil's orange juice production is exported. Outside of the Western Hemisphere, the European Union is the other major orange juice-consuming region. Consumption of orange juice in the major consuming regions of the world is shown in Table 2-2.

The United States is nearly self-sufficient in orange juice production. Net imports of orange juice in 1999 were less than 200 million SSE[1] gallons with estimated U.S. consumption at 1.6 billion SSE gallons (Florida Department of Citrus 2000). Despite the small importance of imports, the United States maintains a sizeable import tariff, which currently is US$ 0.297 per SSE gallon for FCOJ and US$ 0.175 per SSE gallon for not-from-concentrate orange juice (NFC). The United States currently provides a trade preference to Israel, Andean Trade Pact Agreement countries and Mexico under the provisions of the North American Free Trade Agreement (NAFTA). South Africa, Belize and Costa Rica, as well as other Caribbean countries, are provided tariff-free access to the United States, the latter under the Caribbean Basin Economic Recovery Act (CBERA).

Table 2-2. Processed Orange Consumption by Country, 1998[a].

Country	Consumption (1,000 MT)	Per Capita (kg)
European Union	13,745	36.70
United States	11,773	42.96
Canada	1,241	40.60
Australia	276	14.91
Mexico	273	2.85
Brazil	243	1.47
Japan	208	1.65
Others	1,302	N/A
Total	29,061	4.92

Source: FAO.

[a] Figures presented are fresh fruit equivalent.

[1] Single Strength Equivalent corresponds to a gallon at 11.8 degrees Brix.

The Processed Orange Industry in Florida

The processed orange industry in Florida began its evolution with the development of FCOJ in the late 1940s. Given its convenience and consistent quality, consumption of orange juice from FCOJ soon replaced fresh squeezed juice as the predominant product form in the 1950s. Orange and orange juice production in Florida flourished and the industry expanded rapidly. Florida produced less than 60 million boxes[2] before 1950. By the late 1960s, production had expanded to 120 million boxes. Production continued to expand in the 1970s and reached 206.7 million boxes in the 1979-80 season. In the decade of the 1980s, however, Florida experienced a number of damaging freezes, which severely reduced orange production. In the 1989-90 season, production was 110 million boxes and over one-half of U.S. orange juice consumption was imported from Brazil. The high prices that ensued, however, spurred a major expansion in orange production in southern Florida and production recovered. In the 1997-98 season, orange production was 244 million boxes. Approximately 95 percent of this crop were processed into orange juice.

Although Tropicana (owned by Pepsi) and Minute Maid (owned by Coca-Cola and one of founding processor-growers) are the two largest marketers of orange juice in the United States, orange processing in Florida was historically owned by large family companies such as Griffin, Lykes-Pasco, Alcoma, and Berry. These families had significant plantings of oranges and also possessed the financial resources to invest in processing plants. Instead of marketing the juice themselves, they sold juice to Tropicana, Minute Maid, or directly to large retail chains that packaged and distributed juice under private labels.

In the decade of the 1990s, several interesting developments took place in Florida. In Tables 2-3 and 2-4, the Florida citrus processors operating in the 1989-90 and 2001-02 seasons are shown, respectively. The processors have been classified by their governance structure and listed as grower-processor, cooperative, or processor-only. The definition of a grower-processor is that a significant proportion of the fruit processed is derived from its own groves, also known as partial BVI. All processors in Florida are net buyers of fruit (i.e., they need to procure fruit on the market to supply their juice plants). In the 1989-90 season there were 29 plants operated by 27 firms, with Minute Maid and Tropicana each operating two plants. Of the 27 firms, 11 were grower-processors, five were cooperatives, and 11 were processor-only. Public data is not available to provide market shares, however, of the processor-only companies, Tropicana and Procter and Gamble were the two largest processors.

Table 2-3. Florida Citrus Processors, 1989-90 Season.

Grower-Processor (11 firms and 12 plants)	Cooperative (5 firms and 5 plants)	Processor (11 firms and 12 plants)
Alcoma	Citrus World	Adams Packing
B&W Canning	Golden Gem	Ardmore Farms
Berry	Holly Hill	B.C. Cook
Caulkins	Ocean Spray	Caribbean Select
Citrus Service	Winter Garden	Citrus Belle
Frostproof Groves		Erly Juice
Indian River Foods		Juice Bowl
Lykes-Pasco		Procter & Gamble
Minute Maid (2)		Sun Pac
Auburndale		Sun Pure
Leesburg		Tropicana (2)
Orange-Co		Bradenton
Silver Springs		Ft. Pierce

By the 2001-02 season, there had been significant changes in the owners and governance structure of the processing sector. In that season, there were 12 firms

[2] One box contains 90 pounds of oranges.

operating 18 plants. Cutrale, the largest processor in Sao Paulo, entered the Florida market by purchasing the Minute Maid plants. The citrus groves owned by Minute Maid had been sold earlier to a group affiliated with the King Ranch, based in Texas. Reflecting a trend towards consolidation in the processing sector, Sun Pure purchased Indian River Foods, giving it two plants while Citrus World, the largest citrus processing cooperative in the world, purchased Sun Pac. As it can be seen, however, by comparing Tables 2-3 and 2-4, the most significant development was the shift away from integrated grower-processors to a separation of orange production from orange processing. Neither of the two plants vertically integrated with orange growing in 2001-02 is a "survivor" from the 1989-90 season. Duda purchased the Citrus Belle plant in the 1990s, and Southern Gardens was a new plant owned by U.S. Sugar, which is also a major orange grower.

Table 2-4. Florida Citrus Processors, 2001-02 Season.

Grower-Processor (2 firms and 2 plants)	Cooperative (3 firms and 4 plants)	Processor (7 firms and 12 plants)
Duda	Citrus World	Cargill Citro Pure
Southern Gardens	Lake Wales	Avon Park
	Bartow	Ft. Pierce
	Holly Hill	Frostproof
	Ocean Spray	Citrosuco
		Cutrale
		Auburndale
		Leesburg
		Dreyfus
		Indiantown
		Winter Garden
		Peace River
		Silver Springs
		Tropicana
		Bradenton
		Ft. Pierce

Among the other companies operating in 1989-90, Alcoma was sold to the Brazilian-based firm Citrosuco, with the orange groves remaining with the Updike family. Berry chose to close its processing plant, while it remains a major citrus grower. Lykes-Pasco also closed its plant, but still remains a major orange grower in Florida. The processing plant affiliated with Orange Co. was recently sold to Vitality Beverages and the groves owned by Orange Co. were sold to another entity. B & W Canning, Citrus Service, Frostproof Groves, Adams Packing, Ardmore Farms, Caribbean Select, and Erly Juice closed. These seven plants were likely victims of the relocation of orange production after the freezes of the 1980s and their small size. Silver Springs is another small processor that lost its orange groves to freezes, but has survived. Golden Gem went bankrupt in 2001, B.C. Cook has been on and off intermittently, Juice Bowl has become strictly an institutional packager for Blue Bird, and Sun Pure has been acquired by Cargill.

Besides the entry of Cutrale and Citrosuco into Florida, Cargill purchased the processing plant formerly owned by Procter and Gamble. Dreyfus purchased the Indiantown Caulkins processing plant and the Winter Garden processing cooperative, operating them as processor-only plants. These purchases add a new dimension of internationalization to Florida's industry since Cutrale, Citrosuco, Cargill, and Dreyfus are four of the five largest processors operating in Sao Paulo. According to industry sources, their aggregate market share in the Florida market in 2000-01 is believed to be around 47.2 percent.

Before we leave our discussion of the Florida processed orange industry, two important factors should be noted for the analysis in this paper. First, in Florida the basis

of payment for oranges used in processing considers the soluble solids content of the fruit, measured in pound solids. After a grower's fruit is harvested, it is weighed at the processing plant to establish the number of boxes delivered. Then, a sample of the fruit is tested for juice content and percentage of sugar (degrees Brix). Individuals who work for the state of Florida conduct this test. The results of the test establish the pound solids of juice per box. Growers are then paid for the pound solids per box delivered to the processing plant.

Second, Florida citrus growers have two major organizations that work for their benefit along with several smaller entities. Florida Citrus Mutual is the largest grower organization. Mutual performs many tasks for its members, but the two most important are probably market news and political lobbying. Mutual publishes a weekly newsletter that provides market news for both fresh and processed citrus. It has also been active in trade negotiations for GATT (the General Agreement on Trade and Tariffs), NAFTA, and FTAA (the Free Trade Area of the Americas), promoting the interests of Florida citrus growers. The Florida Department of Citrus (FDOC) is the state agency that administers the generic advertising program funded by a grower-authorized tax levied on every box of citrus sold in Florida.[3] The FDOC advertising program has long been recognized as one of the most successful promotion programs in U.S. agriculture (Capps et al.2003).

Other organizations that work to support Florida citrus are the Florida Fresh Fruit and Vegetable Association (FFVA), the Florida Farm Bureau Federation, the Indian River Citrus League, Gulf Citrus Growers, the Florida Citrus Processors Association (FCPA), and Florida Citrus Packers. Florida Agricultural Statistics Service (FASS)

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[3] A small proportion of fruit escapes taxation because it is marketed through informal channels. Such fruit is called non-certified shipments.

works in collaboration with the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (USDA) to produce useful data related to citrus, including production and marketing figures by citrus variety and use as well as grower (on-tree) prices.

The Processed Orange Industry in Sao Paulo

The processed orange juice industry in Sao Paulo had its origins in the early 1960s thanks to the freeze that damaged Florida orange groves in 1962. Due to the need to find another production area for oranges in order to meet the growing market in North America, Sao Paulo arose as an investment opportunity for orange juice processors and exporters. Lykes-Pasco, a large integrated grower-processor in Florida, entered Sao Paulo and formed Citrosuco in a joint venture with the German-Brazilian group Fischer, a family-owned company. FCOJ exports from Brazil grew from 5,000 MT of FCOJ in 1963 to more than one million MT in 2000. FCOJ produced in Sao Paulo is responsible for 98 per cent of the total FCOJ produced in Brazil.

In the 1960s, the domestic market for fresh oranges was the most important market for oranges produced in Sao Paulo. As the processed orange utilization grew rapidly in the 1970s, processors started procuring oranges through fixed price contracts, seeking a more stable supply and reductions in transaction costs. Helped again by a series of freezes in Florida in the 1980s, the Sao Paulo citrus industry received another thrust and it grew even more.

From the late 1980s until the 1992-93 season, transactions between growers and all processors were based on a standard contract, which functioned very much like a participation contract. A key underlying assumption of this standard contract was that

processors were assumed to have the same operational costs and juice yield from processed oranges. The one exception to this standard contract was Frutesp, a citrus processing cooperative owned by citrus growers, which used to pay its growers a higher price as a result of its claimed lower operational cost and higher yield established in contract.

Under the standard contract, growers received payments in installments, according to the average price of FCOJ over the season at the New York Mercantile Exchange, based upon a fixed and common yield established by the processors (i.e., a certain number of boxes per metric ton of FCOJ), adjusted for the cost of producing and exporting FCOJ, also jointly established by processors. Then, the final price to a grower would be the positive (or even negative) net price after subtracting all the costs incurred and agreed *ex ante* throughout the corresponding season. From the processor standpoint, standard contracts offered lower transaction costs by assuming a commitment between the processor and the grower, in a kind of quasi-partnership (Andia 1998) "in which there [was] a residual hazard" (Williamson 1996, p. 377).

With the recovery of the Florida citrus industry in the 1990s, futures prices began falling and Brazilian citrus growers decided that the standard contract was no longer advantageous to them, since processors refused to lower the costs they used to charge according to the new reality of low FCOJ prices. Therefore, growers, not willing to solely assume the burden of price risk, became more and more discontent and put pressure to eliminate the standard contract. Citrus growers filed an antitrust lawsuit against the processors and the Brazilian Trade Commission (CADE) stepped in and

abolished the standard contract in 1994. As a result, free negotiation between growers and processors became the rule.

Adapting to the new institutional environment, processors, besides proposing spot prices, also began offering long term contracts in an attempt to insure long-run supplies of fruit. In addition, processors expanded production from their own properties. Today, Cutrale and the Fisher family, who control Citrosuco, are the two largest orange growers in Sao Paulo. Processors have also made use of toll processing.[4]

Nevertheless, with all of the changes in the system of contracting, the payment based on boxes as opposed to pound solids has been maintained. It is expected that under a payment based upon pound solids, processors may well see their average procurement costs increase. Andia (1998), after analyzing net margins received by citrus growers and processors over the period 1964 through 1997, in a box-based payment scenario and in a pound solids-based payment scenario, recommended, in distributive terms, a payment system based upon the former standard contract with a basis of payment in pound solids as opposed to boxes.

Despite the entry of Citrovita in 1989 and Cambuhy in 1992, a process of concentration and consolidation in the processed orange industry of Sao Paulo occurred in the 1990s. In 1993, Frutesp, a Brazilian-owned cooperative was bought by Dreyfus, a French group that already had entered into Brazil when it acquired Frutropic in 1988. In 1994, Cambuhy merged with Montecitrus, a toll-processing group of citrus growers, becoming Cambuhy-MC. In 1998, Citrovita acquired Cambuhy-MC. In 1999, CTM

[4] The term "toll processing" refers to the case where a processor crushes fruit for a grower for a fixed fee, but the grower maintains property rights of the juice.

Citrus shut down its processing plant; Cutrale rented Branco Peres and became the sole buyer of Sucorrico's production. In 2000, Branco Peres rented the Royal Citrus plant.

In 2000, there were 10 major processors operating 17 plants for a universe of about 20,000 unorganized (Fernandes Jr. 1998) citrus growers in Sao Paulo. Cutrale operates 4 plants, Citrosuco (2), Cargill (2), Dreyfus (2), Citrovita (2), Bascitrus (1), Sucorrico (1), Kiki (1), Royal Citrus (1), and JLG (1).

The Sao Paulo processed orange industry may be considered as an oligopsony, where the control of fruit procurement is under a few processors, the five largest are responsible for about 80 percent of Brazilian FCOJ exports (Table 2-5).

Table 2-5. Brazilian FCOJ Export Share by Processor, in Percentage of Volume (MT), 1990-91, 1997-98, 1999-00 Seasons.

Exporter	1990-91	1997-98	1999-00
Cutrale	28.2%	27.7%	27.3%
Citrosuco	19.8%	25.5%	24.8%
Citrovita	0.0%	16.8%	12.3%
Dreyfus	22.1%	12.2%	9.7%
Cargill	10.7%	12.0%	4.3%
Sub-Total	80.7%	94.2%	78.4%
Others	19.3%	5.8%	21.6%
Total	100.0%	100.0%	100.0%

Source: Leme (1999); Neves et al. (2000).

Processors in Sao Paulo are cost efficient in fruit procurement, processing and logistics, chiefly in bulk transportation through trucks and vessels as well as ownership or partnership of port terminals. With that, it seems clear that the citrus industry in Sao Paulo is geared to exporting orange juice (Table 2-6). Strategic alliances have been formed between citrus processors and distributors of dairy products, however, especially for NFC distribution in South America, such as Cargill with Nestlé and Citrovita with Danone, since demand for NFC products in Brazil has increased dramatically. According to Abecitrus estimates, consumption of NFC orange juice in Brazil has increased from

0.8 million SSE gallons in 1993 up to 52.8 million SSE gallons in 2000, utilizing approximately 9 million boxes, a small portion of the crop. Unlike Florida, the processed orange industry in Sao Paulo, however, is not vertically integrated into international distribution.

Table 2-6. Estimates of Orange Utilization in Brazil, in Million Boxes, from 1985-86 through 1999-2000 Seasons.

Year	Production		Export		Processing		Domestic Consumption	
	Quant.	%	Quant.	%	Quant.	%	Quant.	%
1985	267.3	100.0	2.7	1.0	200.5	75.0	64.1	24.0
1989	357.0	100.0	3.6	1.0	261.0	73.1	92.4	25.9
1990	317.4	100.0	1.9	0.6	217.0	68.4	98.5	31.0
1991	343.1	100.0	2.7	0.8	232.0	67.6	108.4	31.6
1992	361.0	100.0	2.0	0.5	275.0	76.2	84.0	23.3
1993	374.0	100.0	2.5	0.7	255.3	68.3	116.2	31.0
1994	381.0	100.0	3.3	0.9	261.0	68.5	116.7	30.6
1995	404.0	100.0	3.2	0.8	271.3	67.2	129.5	32.0
1996	432.4	100.0	3.0	0.7	284.4	65.8	145.0	33.5
1997	455.0	100.0	3.0	0.7	345.0	75.8	107.0	23.5
1998	330.0	100.0	0.0	0.0	279.0	84.5	51.0	15.5
1999	388.0	100.0	0.0	0.0	280.0	72.2	108.0	27.8

Source: Leme (1999).

Sao Paulo citrus growers have two major organizations which work for their benefit: Associtrus (The Brazilian Association of Citrus Growers), founded in 1974, which is the only citrus growers association recognized by Abecitrus (The Brazilian Association of Citrus Exporters), although it has few members and lacks representativeness; and Fundecitrus (Fund for Citrus Plant Protection), founded in 1977, an interprofessional organization maintained by processors and growers, which contribute to a per-box rate based upon quantities negotiated between them. Fundecitrus has basically been in charge of monitoring, eradicating and avoiding the spreading of citrus canker in the citrus area as well as coordinating the research program on CVC (citrus variegated chlorosis), blight, and the sudden death of citrus disease more recently.

Problem Statement and Hypotheses

Earlier in this paper, it is noted that theory suggests that the Florida citrus processing industry would have strong incentives to backward integrate and own orange groves. However, during the past 12 years, the exact opposite has happened, with a significant trend towards separate ownership of orange groves and orange processing facilities. In contrast, there still is a high degree of partial vertical integration between growing and processing in Sao Paulo just as there was in the early 1990s. How can this apparent quandary between theory and empirical observation in Florida be explained? The paper's two hypotheses are: some issues related to governance structures are the underlying explanatory factor for the current trend towards separate ownership of groves and processing facilities in the Florida citrus industry; and some of the issues above and others related to governance structures are the underlying explanatory factor for the current trend towards backward integration in the Sao Paulo citrus industry.

Methods

Following Ronald Coase's advice, "to understand the effect of different institutional arrangements on the working of the economic system, the obvious way to do this is to compare what happens in different countries with differing arrangements," (Coase 1991) and also within the same country over time.

This paper presents a comparative study of the current situation of the governance structure between processing and growing in Florida with two other cases in citrus processing: Florida citrus 12 years ago and Sao Paulo citrus today. In both comparisons, it is found that empirical observation is in line with the predictions of BVI theory.

For the analysis, based on theories of New Institutional Economics described in the beginning of this paper, issues related to governance structures are used as the underlying explanatory factors for the current and past degrees of BVI observed in Florida and Sao Paulo.

The issues (i.e., potential explanatory variables) selected for the analysis of the case comparing the Florida citrus industry in the late 1980s to the Florida citrus industry in 2001, though not necessarily in order of importance, are: NFC; freeze risk, costs of labor (on farm), capital needed to have a grove big enough to supply a processing plant, water usage regulations, and investment risk aversion.

Regarding the case comparing the current state of the Sao Paulo citrus industry to the Florida citrus industry in 2001, the issues (i.e., potential explanatory variables) selected for the analysis, though not necessarily in order of importance, are: costs of labor (on farm), capital needed to have a grove big enough to supply a processing plant, level of concentration in the processing sector, payment structure, target markets, price risk management, investment risk aversion, and drought risk.

Analysis

Comparing the Florida Citrus Industry in the Late 1980s to the Florida Citrus Industry in 2001

Table 2-7 lists the explanatory issues as to why the governance structure in Florida has changed over the last 12 years from a partly backward vertically integrated scenario to one with ownership separation between growing and processing. The theory reviewed in this paper suggests, among other reasons, that due to the perishability of oranges, known as temporal specificity, processors would have a strong incentive to

backward integrate, which is to assure steady supply of raw material. Below there are some issues that explain why observed behavior differs from predicted theory.

Table 2-7. Comparing the Florida Citrus Industry in the Late 1980s to the Florida Citrus Industry in 2001.

Issue	Florida Citrus in the Late 1980s	Florida Citrus Today
NFC	minor segment	40% U.S. market
freeze risk	very high	low
costs of labor (on farm)	moderate/high	very high
capital needed to have a grove big enough to supply a processing plant	high	very high
water usage regulations	stringent	very stringent
investment risk aversion	moderate	high

Nfc

In mid 1980s, consumption of NFC orange juice in the U.S. market was minor. Currently, it reaches 40 percent of the American market. NFC is a product that requires assets of higher specificity, whether it is for procurement (Valencia-type of oranges), processing (pasteurization), storage (more costly tanking farms, because NFC contains water and the tanks have to be aseptic) or distribution (transportation of "water"). Additionally, NFC has a "willingness to pay a premium specificity," and processors do not want to miss that chance to make profit out of it; which could also explain why they would have some degree of BVI. Therefore, it should be expected from theory the level of BVI is higher as NFC market participation increases. However, this is not what is observed in the Florida orange processing industry. Tropicana, e.g., the leading producer of NFC, only owns a small grove operation and cannot be considered as a backward vertically integrated processor; Tropicana is actually a forward vertically integrated firm into distribution. Other significant producers of NFC, such as Southern Gardens (a

Tropicana supplier) and Citrus World, are partly backward vertically integrated and both backward and forward vertically integrated, respectively.

Freeze risk

In the 1980s, Florida processors owned grove operations close to their processing facilities, known as "site specificity" (Williamson 1985, p. 95), also as a means of guaranteeing at least a minimal supply in the event of mild freezes that used to be a commonplace in the citrus belt at that time. However, since their orange production was drastically reduced to half by the sequence of widespread severe freezes in the 1980s, that adverse scenario spurred a major expansion in orange production in southern Florida, then rid of freezes, during the 1990s, but very costly to bear along with the already heavy losses suffered with their own groves and plants. It should be expected that without freeze risk processors would tend not to backward vertically integrate, since they no longer need to protect themselves from crop shortages due to freezes.

Costs of labor (on farm)

Over the decade of the 1990s, labor on farm has become more and more scarce, litigious, and thereby expensive. Concerns about illegal markets have made processors distance themselves away from lawsuits filed by labor organizations and transferred then all those risks to the market. For example, the case of the United Farm Workers in Florida illustrates the susceptibility that Coca-Cola faced when Minute Maid sold its groves and was under threat of boycott by the labor market. It should be expected that with more expensive labor on farm, processors would tend not to backward vertically integrate, since they could procure enough raw material less riskily on the market to meet their needs.

Capital needed to have a grove big enough to supply a processing plant

With the freezes, south Florida land values skyrocketed in the 1990s, which discouraged processors, which were in a difficult financial situation due to the freezes, to buy new tracks of land in Southern Florida, whose tillage costs are higher. Unless there is a strategic purpose at stake, it should be expected that with more expensive land, processors would tend not to backward vertically integrate, since they could procure enough less costly raw material on the market to meet their needs.

Water usage regulations

The trend seems to be away from BVI as Cutrale has given up the rights to purchase 14,000 acres in Okeechobee County to develop its first grove in Florida. According to industry sources, the main reason for that are the extreme restrictions imposed on water usage by the South Florida Water Management District. This is an example of the difficulty to develop the land for citrus production in Florida, but it does not exclude the possibility of buying established groves with water rights.

Investment risk aversion

Another factor that may preclude Florida processors from backward vertically integrating is a heightened investment risk aversion among processors. As Arrow argues:

> ... it is not clear that risk aversion provides much of an incentive to vertical integration. If demand for the final product is highly elastic, then it is easy to show that upstream sales and downstream profits are positively correlated. Hence, [BVI] does not seem to be the best possible portfolio diversification. (Arrow 1975, p. 182)

Vertical integration, thus, may lead to more vulnerability within a processor's investment portfolio, an extremely important factor if processors have become more risk adverse.

Comparing the Sao Paulo Citrus Industry to the Florida Citrus Industry in 2001

Table 2-8 lists the explanatory issues as to why there is a difference between the governance structure of the orange processing industries in Florida and Sao Paulo. Below there are some issues that explain why observed behavior in Sao Paulo is in compliance with what theory predicts.

Table 2-8. Comparing the Sao Paulo Citrus Industry to the Florida Citrus Industry in 2001.

Issue	Florida Citrus Today	Sao Paulo Citrus Today
costs of labor (on farm)	US$ 1.550/box	US$ 0.293/box
capital requirements	US$ 125 to US$ 231 million	US$ 75 million
level of concentration in the processing sector	moderately high (top five firms = 50%)	oligopsony (top five firms = 80%)
payment structure	by pound solids (i.e., quality driven)	by boxes delivered (i.e., quantity driven)
target	domestic for FCOJ and NFC; exports of both are secondary markets	export of FCOJ, domestic for fresh oranges (25%), with minor (5%) markets
price risk management	easy access to futures markets/hedging	limited access to futures markets/hedging
investment risk aversion	moderate	low
drought risk	relatively low since use of irrigation almost universal	relatively high since use of irrigation is small

Costs of labor (on farm)

In Florida, labor on farm is scarce, has to deal with illegal workers and a more litigious environment, faces competition from other labor markets, and thereby is very costly. In Sao Paulo, though, labor is moderately cheap. Spreen et al. (2003b), from a survey with Sao Paulo and Florida growers for season 2000-01, estimated the cost per box for picking oranges from trees and roadsiding at US$ 0.293 and US$ 1.550, respectively. It should be expected that with cheaper labor on farm processors would tend to backward vertically integrate, since they could still procure raw material on their own groves to meet their strategies at a relatively low labor cost.

Capital needed to have a grove big enough to supply a processing plant

This issue relates to the capital requirements for citrus growing and processing in Florida and Sao Paulo. A processing plant with a capacity of 10 million boxes is generally considered the minimum size needed to attain the economies of scale associated with citrus processing. In Florida, citrus yields generally range from 300 to 400 boxes per acre, so that 25,000 to 33,000 acres of production are needed to supply a 10 million-box plant. The cost to develop a citrus grove in Florida ranges from US$ 5,000 to US$ 7,000 per acre (Muraro et al. 2000). Hence, the capital investment required to supply a modest-sized processing plant in Florida is between US$125 million and US$231 million.

In Sao Paulo, Neves (2000) reports that new grove development is approximately US$ 3,700 per hectare or approximately US$ 1,500 per acre. Yields in Sao Paulo are somewhat lower compared to Florida, 200 boxes per acre is typical (although yields in irrigated groves can be substantially higher). Thus, 50,000 acres would be needed to supply a 10-million-box plant, which would require a capital investment of US$ 75 million. Therefore, the capital investment required in Sao Paulo to be fully backward vertically integrated is substantially lower than that needed in Florida. In spite of that, such financing costs minimization may occur at the expense of higher transaction costs, which can compromise the total cost minimization associated with a determined governance structure of choice in the Sao Paulo institutional environment.

Likewise, one could argue that processors in Florida have compared the reduction in transaction costs realized from BVI accompanied by high capital requirements needed to own large tracts of citrus and concluded that the total cost savings from this governance structure do not offset the transaction plus production costs savings

associated with no investment in an illiquid highly specific asset (i.e., no BVI). Even though the credit system in Brazil is more costly to borrowers, such capital restrictions impose a smaller burden on processors, who are better capitalized than independent mid-size growers.

Level of concentration in the processing sector

In Sao Paulo, the five largest firms account for over 80 percent of processed orange exports, whereas Florida's five largest processors account for approximately 50 percent of processed orange production. It should be expected from theory that the higher the degree of concentration in the processing sector the more likely processors will backward vertically integrate, for several reasons, among others, such as to help leverage their power in bargaining and set barriers to non-integrated competitors.

The levels of concentration in Florida and Sao Paulo were calculated by using the Herfindahl-Hirschman Index (HHI), which is given by the sum of the squares of each processor's share, which were obtained from industry sources. In a monopoly, HHI would be equal to 10,000. Low concentration is expressed by HHI less than 1,000. Moderate concentration is between 1,000 and 1,800. High concentration is greater than 1,800. In season 2000-01, for Florida, HHI equaled 1,426.1 and for Sao Paulo, HHI equaled 1,704.2. Therefore, Sao Paulo, although higher, is within the same bracket of degree of concentration as Florida, namely moderate level of concentration, according to the Herfindahl-Hirschman Index.

Subliminally, differences in the level of organization of growers between Florida and Sao Paulo countries may also help explain the differences in the degrees of BVI.

Florida growers are better organized to combat opportunistic behavior from processors than Sao Paulo growers are.

Payment structure

Since the processor also knows the quality demands of its customers, through BVI he/she can more readily affect the mix of orange varieties, each of which possesses their own unique set of quality attributes. Under a payment based upon quantity only, this factor may well be one explaining why vertical integration dominates in Sao Paulo. Additionally, in such a basis of payment, BVI arises as an alternative to the fact that "it may be extremely costly to write a contract that specifies unambiguously the payments and actions of all parties in every observable state of nature" (Grossman and Hart 1986, p. 695). Florida has chosen a different governance structure, in which processors pay for the sugar content of the oranges and thereby signal growers for at least one of the attributes they desire. This way, backward integration is not necessary to accomplish this task.

Target markets

Since the Sao Paulo processed citrus industry is geared towards exportation and a guaranteed supply to long term foreign customers is a key factor for the permanent success of the business, Brazilian-based processors have partly backward vertically integrated in order to guarantee supply to honor their commitments. Florida, by its turn, is different, being more geared to the domestic market, firstly because it has never been self-sufficient (i.e., a net exporter) and secondly because it has always been able to rely on the consistent quality of the Brazilian orange juice supply, which might also explain Florida's preference for non-backward integration.

The nature of the Brazilian citrus industry is quite different from the Floridian one. For example, the distribution sector in Brazil is still embryonic, whereas in Florida, with a stronger domestic distribution market, processors are more likely to be forward vertically integrated, such as Tropicana and Citrus World. Minute Maid, however, has chosen to operate strictly as a marketing firm, buying all of its juice from other companies.

Price risk management

According to industry sources, since in Florida processors always have the possibility of obtaining juice for their marketing programs from the futures market, therefore giving themselves a supply hedge, it is understandable why the degree of BVI is so small there. In Sao Paulo, however, such supply hedge does not exist, since the delivery points for juice are all in Florida. This way, the only option left is BVI as a way of avoiding fruit shortage risk. A backward vertically integrated processor in Florida, though, would be more likely to hedge its fruit via cash juice sales instead of using futures.

Investment risk aversion

By assuming that there is some degree of investment risk aversion among Florida processors, and citrus growing itself offers enough risks such as diseases, in order to avoid portfolio vulnerability, it should be expected from theory that BVI is not the choice. Maybe the backward vertically integrated Sao Paulo processors are willing to take more risk, since they are more accustomed to taking risks due to the own nature of the Brazilian institutional environment, which is typical of a developing country.

Drought risk

In Brazil, a few processors compete for many orange suppliers. Although they are large in number, these same growers may have their production harshly limited by a severe drought for instance, whose resulting shortage in the season crop represents a sufficiently strong incentive for processors to partly backward vertically integrate, which is a means of reducing supply assurance concerns. On the other hand, Florida is virtually all irrigated, which reduces dramatically the vulnerability of its citrus industry to severe and prolonged droughts for example, and therefore the need for backward integration.

Synthesis of Results and Concluding Remarks

Since its outset in the 1950s, when FCOJ was introduced, the world processed orange industry has experienced important challenging turning points. In 1962, the Florida freeze gave Brazil the conditions to start growing rapidly. Money years came as a result. In the 1980s, a new series of hard freezes in Florida helped open the door for more and more Brazilian imports and shifted the production region south in Florida. The 1990s were characterized by Florida recovery, consolidation in the industry, and internationalization, with processors owning facilities both in Brazil and Florida.

Markets in both Florida and Sao Paulo exist in a less than purely competitive framework, whose institutions (i.e., the rules of the economic game) play as key factors that shape the governance structures of organizations. It is important to make clear that despite Florida and Sao Paulo belonging to different institutional environments, they are subject to the same analysis.

From the two cases analyzed in the previous section, one can argue that the different governance structures that have evolved in the processed orange industries in

Florida and Sao Paulo are the result of the different institutional environments that existed and still exist in the United States and Brazil. This case provides an empirical example to substantiate the assertion that "to explain the scope of any firm, one must consider the overall network of production and distribution relations" (Bolton and Whinston 1993, p. 121). These authors criticize the fact that the literature by Williamson and others has only contemplated bilateral relationships, which is "rarely descriptive of reality." In the case of both the Brazilian and Florida processed orange industries, trading relations are multilateral, whether it is due to the large number of citrus growers or to the wide range of distributors, wholesalers and retailers.

In order to broaden the institutional approach to the empirical case of this paper, two comparative analyses were conducted. Each one identified issues most closely related to governance structure variables so as to explain why there are differences between the two scenarios in comparison and if they are in line with economic theory. This paper shows that the selected explanatory variables above are the ones most often different under the differing case scenarios.

As a result of the first analysis, the level of BVI in the Florida orange processed industry in 2001-02 is much lower than the one found in 1989-90 because, in the former: there is lower freeze risk in the citrus growing area; the costs of labor on farm are higher; the capital required to own a grove operation to supply a 10 million processing plant is greater; water usage regulations are more stringent; and Florida processors' investment risk aversion is assumed to be higher.

Interestingly, one variable out of six, name NFC, apparently is not in compliance with the role that asset specificity plays in transaction costs economics. The fact that in

2001 NFC is responsible for 40 percent of the American market is not sufficient to make processors backward vertically integrate into owning grove operations. Further investigation is needed to learn more about the networking intricacies among processors that produce NFC, such as Tropicana (forward vertically integrated into distribution), Citrus World (partly backward and forward vertically integrated cooperative), Southern Gardens (partly backward vertically integrated and Tropicana's supplier), Cutrale (Minute Maid's supplier), and Citrosuco (Tropicana's supplier). The reason for this deviation from theory's prediction may rely upon four assumptions, such as: either it is for strategic purposes that NFC Florida processors are not backward vertically integrated; or the gains that would be obtained from BVI do not outweigh the aggregate effect of the other five listed variables; or these processors have a sufficient number of long-term contracts with growers and other processors that guarantees a steady supply of Valencia oranges to produce NFC; or processors are mistaken, which is very unlikely.

As a result of the second analysis, in 2001-02, the level of BVI in the Florida orange processed industry is much lower than the one observed in Sao Paulo because of the following eight explanatory issues: the costs of labor on farm are five times lower in Sao Paulo; the capital required to own a grove operation to supply a 10 million processing plant in Sao Paulo is more than two times lower as compared to Florida; the five largest processors in Sao Paulo account for 80 percent of the processing capacity whereas the ones in Florida account for 50 percent, which gives Sao Paulo processors an edge in fruit procurement bargaining and help them set barriers to new competitors; Florida pays based on pound solids whereas Sao Paulo pays by boxes with BVI, since this way they not only lower their procurement cost but also circumvent the problem of

contract incompleteness; Sao Paulo is more geared to exportation whereas Florida is to the North American market; Florida can use futures markets for hedging more easily than Sao Paulo; Sao Paulo processors' investment risk aversion is assumed to be low; and Sao Paulo does not have a steady supply assurance since most of its orange groves are not irrigated.

In this paper, the governance structures of the orange processing industries of Florida and Sao Paulo have been reviewed. At the beginning of the 21st century, the institutional arrangements that have evolved in the two regions are quite different. An intriguing question: is BVI a superior model compared to separate ownership of orange growing and processing in terms of economic efficiency? The answer is that the processing industry in each region has optimally adapted to the institutional environment that exists in each region.

Questions facing the industry include which companies will be able to take advantage of changes in trade policy and penetrate new markets. Will the alliances formed between major U.S. marketing companies such as Tropicana and Minute Maid and the large Sao Paulo-based processors now present in Florida be strengthened? What role will multinational companies such as Cargill and Dreyfus play in the future? Despite its higher costs of production, does Florida have inherent advantages or disadvantages because of the more supportive and protective institutional framework that has evolved in the United States? Well, let us leave these questions to be answered in future essays.

CHAPTER 3
THE ROLE OF BRAZIL IN THE WORLD ORANGE JUICE MARKET: A THREAT POSED BY CITRUS VARIEGATED CHLOROSIS

Introduction

In Brazil, citrus production is concentrated in the state of Sao Paulo, which represents nearly 85 percent of Brazilian production and virtually all Brazilian exports of FCOJ (frozen concentrated orange juice). The Sao Paulo citrus industry in Brazil is comprised of more than 20,000 citrus growers, 333 municipalities, 400,000 jobs in Sao Paulo, US$ 1.5 billion in annual exports (US$ 1.3 billion in juice, mostly FCOJ, fresh orange, pulp pellets and essential oils in 1999), and a total worth of US$ 5 billion (Neves et al. 2000).

The processed orange industries of Florida and Sao Paulo dominate the world market for orange juice. These two states in aggregate produce more than 85 percent of the orange juice consumed in the world. Florida and Brazil produce 37 percent and 48 percent, respectively (FAO 2003).

Unlike Florida, Sao Paulo is the only major orange producing region in the world affected by CVC (citrus variegated chlorosis), a bacterial disease present in over one-third of the orange trees in Brazil (Fundecitrus 2003). Much research and investment has been focused on sequencing and analyzing the causal bacterium of CVC, *Xylella fastidiosa* (Chang et al. 1993), in Brazil in an attempt to find a cure for the disease. So far, Sao Paulo has lived with CVC by adopting various measures of control including pruning of affected branches and eradication of highly diseased plants to remove the

inoculum, spraying of transmission vectors (sharpshooters), and production of seedlings in greenhouses covered by plastic and laterally protected by screens. These measures of control have increased the cost of production.

The economic importance of CVC is incontestable: in 2000, losses were estimated at US$ 250 million (Fundecitrus 2003). Across all sweet orange varieties grown in Brazil, production losses have occurred mostly in plants with severe symptoms; the losses have been felt as reduction in both fruit size and weight. It has been estimated that the production from highly affected trees is about 75 percent below the production from the healthy trees (Ayres 2000). Hence, CVC represents a prominent threat to Brazil's supply and leading role in the world orange juice market.

This paper analyzes the aforementioned threat in the context of a mathematical programming model of the world orange juice market developed at the University of Florida (McClain 1989; Spreen et al. 2003a). Two scenarios are analyzed via a spatial equilibrium model. One scenario considers what might happen in upcoming years if CVC did not exist, while the other scenario provides projections that incorporate the presence of CVC.

In the next section, an overview of the orange production in Sao Paulo is given, followed by a review of recent events in Sao Paulo highlighting the incidence of CVC and the challenges it poses to the Brazilian citrus industry. In the third section, the problem statement and hypotheses with respect to the economic impact of CVC on Brazilian citrus are provided. The fourth section then describes the methods utilized: partial budgeting and adaptation of the spatial equilibrium model of the world OJ (orange juice) market developed at the University of Florida. In the fifth section, an analysis of

the differences in output in Sao Paulo with the presence of CVC and without CVC is provided. Finally, the last section provides some concluding remarks.

Citrus Production in Sao Paulo

Overview

The processed orange industries of Sao Paulo (including the southern part of Minas Gerais State), Brazil, together with Florida, United States dominate the world market for orange juice. Sao Paulo has become the largest citrus production region in the world. The combination of abundant land, good soils, sufficient rainfall to allow reasonable production, and no threat of freezes has allowed the citrus industry in Sao Paulo to become the leader in world citrus production. Brazil also has a wage scale that provides a lower labor cost for citrus production and harvesting compared to the situation in Florida. In addition, the Brazilian citrus industry has made major investments in citrus processing as well as investment in bulk transportation to facilitate the export of orange juice to Europe, North America, and the Pacific Rim. FCOJ produced in Sao Paulo is responsible for 98 percent of the total FCOJ produced in Brazil (Abecitrus 2003).

Round oranges are the most important citrus varieties produced in Sao Paulo. Sao Paulo orange production over the period 1960-61 through 2001-02 is shown in Figure 3-1. Production increased significantly over this period from just over 150 million 90-pound boxes in 1979-80 to a peak of 420 million boxes in 1997-98. This rapid increase in production was spurred by two primary factors. First, a series of freezes that visited Florida and killed millions of trees in December 1962, January 1971, January 1977, and over the decade of the 1980s, in January 1981, January 1982, December 1983, January 1985, and December 1989. As a result, orange juice exports from Brazil grew from

5,313 MT of FCOJ in 1963-64 to almost 1.3 million MT in 1999-00 as shown in Figure 3-2.

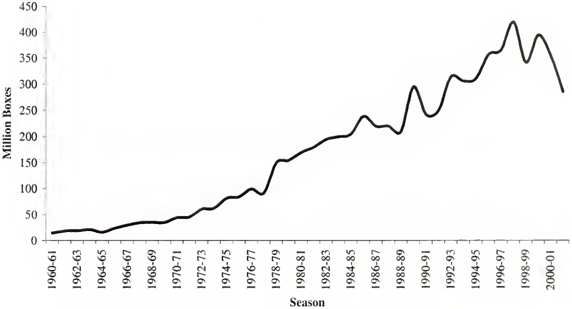

Figure 3-1. Sao Paulo Orange Production, 1960-61 through 2001-02.
Source: FAS (Foreign Agricultural Service); FDOC (Florida Department of Citrus)

Orange production in Florida decreased from 206.7 million boxes in 1979-80 to 110.2 million boxes in the 1989-90 season. World orange prices rose dramatically and significant capital was attracted to orange production. The second factor underlying the growth in Brazilian orange production was improved transportation of FCOJ that sharply reduced the cost of delivering orange juice to the developed economies of North America and Europe. Per capita consumption in both markets grew; in the United States, it is nearly six SSE (single strength equivalent) gallons. A SSE gallon has a Brix of 11.8 degrees Brix. Brix measures the percentage of solids in the juice by weight.

By the end of the 1990s, production in Florida recovered from the low levels realized after the freezes of the 1980s. Florida orange production was 244 million boxes

in 1997-98 and has exceeded or been close to 200 million boxes each season since 1999-00. Large crops in both Sao Paulo and Florida resulted in sharply lower prices in both the 1999-00 and 2000-01 seasons (Figure 3-3). In turn, lower prices have curtailed the rate of new plantings in Sao Paulo as shown in Figure 3-4.

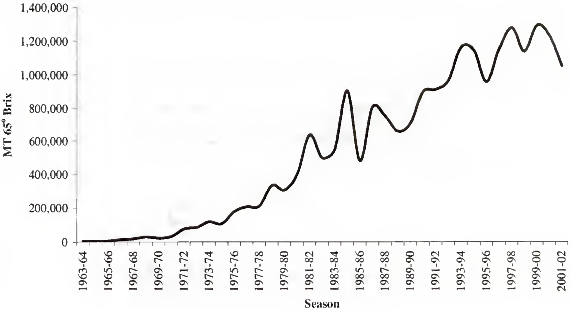

Figure 3-2. Brazil FCOJ Exports, 1963-64 through 2001-02.
Source: FAS; FDOC.

Orange production in Sao Paulo is concentrated in the northern half of the state. An outbreak of citrus canker in the 1970s in a production area south of the Tiete River restricted citrus production to areas north of that river. Nearly all of citrus production is in a rainfed system because of minimal available surface water and a deep water table. The distribution of rainfall in Brazil is such that a rainfed system is successful in most seasons. Because of its dependence on rainfall for moisture, however, most citrus trees in Sao Paulo (estimated at 80 to 85 percent by private sources) are budded to Rangpur Lime rootstock, which is highly tolerant to drought. Rangpur Lime, however, is susceptible to

blight, a disease that usually attacks trees after they reach 10 years of age. By 15 years of age, a large proportion of trees is usually lost to blight, and the grove is replanted. More recently, a new disease called "sudden death of citrus" has been found in northern Sao Paulo and southern Minas Gerais. This disease appears to be associated with a strain of the citrus tristeza virus. It is now killing round oranges grafted on Rangpur Lime. Since over 80 percent of the trees grown in Brazil are on Rangpur lime, this new disease is jeopardizing at least 160 million trees.

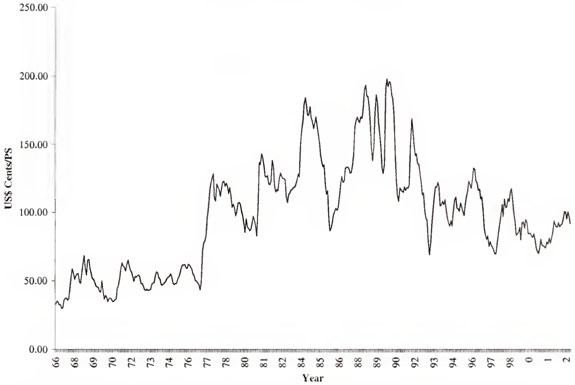

Figure 3-3. New York FCOJ Monthly Average Nearby Futures Settlement Price, 1966-2000.
Source: FDOC.

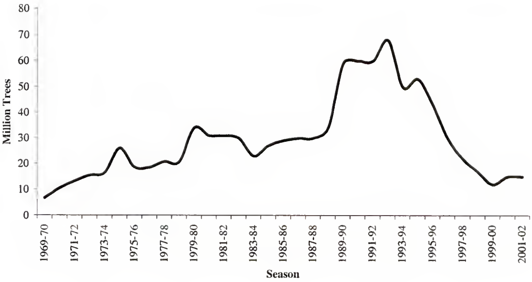

Figure 3-4. Sao Paulo Non-Bearing Tree Inventory, 1969-70 through 2001-02. Source: FAS; FDOC.

Recent Events

Two of the most destructive diseases that affect citrus trees, canker and tristeza, have both been found in Sao Paulo in the past 50 years. As trees planted on sour orange rootstock are susceptible to the citrus tristeza virus (CTV), orange growers reacted by switching to Rangpur Lime and other tristeza-resistant rootstocks. After the citrus canker outbreak of the 1970s, orange growers realized that citrus canker is endemic south of the Tiete River and moved their citrus plantings northward.

With the rapid expansion of orange production in the 1980s and early 1990s, orange growers moved into new production areas in extreme northern Sao Paulo State. New plantings were also established in southern Minas Gerais near the northeast-central boundary of Sao Paulo. These production areas are in a more tropical climate with less rainfall, and usually have drier and warmer winters.

By 1987 (De Negri 1990), a new disease was identified in the northern production areas of Sao Paulo and southern Minas Gerais. This disease results in lesions on the

leaves and smaller fruit with greatly reduced juice content. Fundecitrus, a research organization funded by citrus growers and processors, initiated an intensive research effort. In 1989, the disease was named as citrus variegated chlorosis (CVC). The vector by which this disease spreads is a common group of insects known as "sharpshooters." There is no known treatment to cure CVC, but given the widespread incidence of the various species of sharpshooters associated with CVC, insecticides have some limited success in reducing the spread of CVC. Moreover, Ayres et al. (2002, p. 2) report that "research results showed that the transmission efficiency of five species of sharpshooters … is low, ranging from 1.3 percent to 11.7 percent, which can partly explain the successful use of insecticides in the control of the disease." If this vector were more efficient in transmitting CVC, the problem could be much worse, as, for example, in the case of Pierce's disease in Californian vineyards, whose vector shows a transmission rate above 90 percent.

The incidence of CVC has been higher in the northern production areas because of the drier weather that facilitates the reproduction of sharpshooters and because of the initial large number of unscreened nurseries that supplied contaminated young trees to groves in the area. In 2002, 55.59 percent of all orange trees in northern groves were found to be infected with CVC by Fundecitrus; 43.23 percent of the trees showed symptoms in the leaves and fruits.

By 2000, it was clear that CVC had spread beyond the northern production areas and had moved into older production zones near Matao and Araraquara. It is now believed that poor control of new planting material hastened the spread of CVC. With

the high rate of replanting in Sao Paulo, use of infected young trees became another vector spreading the disease.

CVC is also more lethal to young trees, which helps to explain the sharp decrease in the nonbearing tree inventory that occurred over the 1996 through 2000 period (Figure 3-4). CVC first appeared in the mid 1980s, but was not diagnosed at that time, and young trees infected with the disease were unknowingly planted close to healthy groves, widening the spread of CVC.

CVC can be controlled only through severe pruning of affected limbs or tree removal, and through additional spraying to reduce sharpshooter populations. Therefore, Sao Paulo citrus growers face the prospect of "living with" CVC and the increased production costs and lower yields associated with this disease. Fundecitrus (2003) estimated that in 2001 over 36 percent of all citrus trees in Sao Paulo showed some evidence of CVC, with 24 percent of trees exhibiting "level 2" or more advanced levels of infection.

In plants showing severe symptoms, production losses, notably such reductions in fruit sizes and weights, are about 75 percent when compared to the healthy trees (Ayres 2000). Consequently, on the supply side, CVC has the potential to be a major threat to the prominent role that Brazil plays in the world orange juice market.

Citrus Production with CVC in Sao Paulo

Fundecitrus (2003) studied the intensity and the production impact of CVC on commercial groves in the states of Sao Paulo and southern Minas Gerais' Triangulo from 1996 through 2002. In the survey sample, the incidence of CVC for all varieties from 0 to 2 years of age first increased from 12.29 percent in 1996 to a high in 1999 of 35.69

percent, and then decreased to 2.04 percent in 2002. This decrease was probably due to better control measures at nurseries as well as in the field. A similar pattern of incidence was observed in trees from 3 to 5 years of age: the infection rate was 32.22 percent in 1996, 56.08 percent in 1999 and 23.08 percent in 2002. It should be noted, however, that young trees may not be exhibiting CVC symptoms in the leaves as the disease has an incubation period from five to 18 months (Ayres et al. 2002).

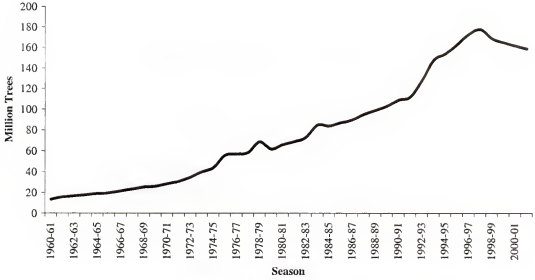

Figure 3-5. Sao Paulo Bearing Tree Inventory, 1960-61 through 2001-02.
Source: FAS; FDOC.

In spite of the encouraging trend observed in the young age categories, it is actually among the adult trees that CVC has been most severe (Figure 3-5). It is no surprise that CVC has progressed in this way, since trees over six years of age (mostly those within the six to 10 age group) are the young trees that were planted from 1986 through 1990 at the early stages of the CVC outbreak. These trees survived somehow, apparently not showing any evident symptoms of CVC that they might be incubated. One may argue that, at that time, since knowledge of current CVC methods of control

was incipient, trees were infected with the bacterium mainly by sharpshooters, not widely sprayed, as well as through the propagation and spread of infected plant material.

For all varieties from 6 to 10 years of age, the incidence of CVC declined from 27.20 percent in 1996 to its lowest level of 25.97 percent in 1998, and then increased to an alarming 53.61 percent in 2002. A similar trend was observed in trees above 10 years of age, with 11.16 and 33.19 percent incidences in 1996 and 2002, respectively.

According to Fundecitrus, in 2002, 38.28 percent of all orange trees in the Sao Paulo citrus belt were infected with CVC. Trees showing symptoms of the disease exclusively in the leaves accounted for 10.36 percent of the total inventory. Those with symptoms both in the leaves and fruit, whether distributed over the whole canopy or just one part, represented 27.92 percent of the total. Although intensity has increased since 1996 when the first survey was conducted, Fundecitrus affirms that the figures observed over the years from 1999 through 2001 statistically do not differ from the ones observed in 2002. Therefore, one may argue that the level of CVC incidence over the last four years has remained relatively stable and under control, perhaps due to the more aggressive and widespread adoption of measures of planting clean young trees grown in protected greenhouses, and pruning, spraying, and nursing older trees.

As expected, the percentage of trees with more severe symptoms of CVC has increased from 6.17 percent in 1996 to 27.92 percent in 2002, with those trees with leaf symptoms only has declined since 1999 from 20.95 percent 10.36 percent in 2002, an encouraging trend suggesting that fewer and fewer adult trees may progress from the relatively mild symptoms to the more severe ones resulting in premature death and, consequently, greater economic loss.

Fundecitrus tree inventory records reflect the impact of CVC. Although not applied to the model of this paper, these data reveal that the population of trees over six years of age has trended upward since 1995-96, except in 1999-00 when it dropped by 10 million trees from the previous season. In 2000-01, the population of trees over six years of age reached about 175 million adult trees. The population of trees under six years old, not yet in full commercial production, has decreased sharply year after year from 71,334,570 trees in 1995-96 to 15,008,096 trees in 2000-01.

In 1998 and 1999, Fundecitrus (Ayres et al. 2002) did a study on yield losses due to CVC. The survey concluded that all main round orange varieties grown in Sao Paulo do not statistically differ in the weight and the number of pieces of healthy fruit, off-grade fruit, and total fruit. Although differences in fruit weight and in numbers of normal and off-grade fruit are statistically significant across distinct levels of CVC incidence, it was found that CVC does not affect the total number of fruit. CVC does, however, affect the total weight of the fruit. Trees with a more acute state of illness in the survey showed an average reduction of 74.98 percent in fruit weight as compared to the fruit weight of healthy trees. An average 43.29 percent reduction was observed in the total weight of both normal and off-grade fruit (with less than 1.97 inches in diameter) when compared to all normal fruits harvested from healthy trees.

Another interesting result from the survey is that lighter CVC symptoms have a more visible effect on young trees compared to older ones. More generalized decay symptoms affect trees of all age categories with the same intensity.

Currently, there is no cure for CVC. Sao Paulo has lived with CVC through pruning affected branches, eradicating highly infected trees, spraying against vectors

(sharpshooters), and producing seedlings in screened greenhouses, which altogether have increased the cost of production by roughly 10 percent according to some industry sources.

The Brazilian citrus industry is in the middle of a transition, in which research is under way for controlling the bacterium and creating resistant plants to the disease. The tree inventory is being renovated by seedlings grown in screened greenhouses, and a new technological and institutional paradigm is being established as a consequence.

The citrus industry in Sao Paulo now accepts the verdict that it will not be able to eradicate CVC and must learn how to manage the disease. A three-pronged management approach is being adopted: 1) beginning January 1, 2003 all new plantings must be trees propagated in screened greenhouses; production of seedling citrus trees in an open-field system for commercial sale will be prohibited; 2) increased scouting to detect CVC infection and aggressive pruning of diseased branches along with eradication of severely affected trees in terminal stages (when pruning is carried out just once, symptoms tend to resurface, and hence a regular pruning schedule is required); and 3) increased spraying to chemically control sharpshooter populations. No single approach by itself is likely to be effective; all three measures of control need to be adopted simultaneously and as early as possible to obtain good results.

Research Problem and Hypotheses

CVC has had notable economic impacts on the Brazilian citrus industry. Definitely, this disease has provoked a sizable supply shock by limiting expansion in production. More generally, the impacts of CVC can be described by: actual and estimated data on reduced orange production (yields); increased death loss/tree removals;

increased cultural care costs, such as pruning, spraying, and scouting; increased costs of new trees, screened greenhouses and regulations; yield losses. Understanding these factors should allow predictions of overall reduced orange juice production and exports, as well impacts on world OJ prices currently and in the future.

Several hypotheses arise with respect to impact of CVC, such as the extent this disease has resulted in: 1) reduced production of Brazilian OJ; 2) reduced trade in OJ between Brazil and its consumers; and 3) increased world OJ prices and related benefits for growers in Florida. In the long run, the impacts of CVC will be affected by the implementation of the new technological path to control this disease. Control measures could result in recovery of Brazil's production to near 400 million boxes by 2009-10 *ceteris paribus*. Using a partial budgeting and an adaptation of a spatial equilibrium model of the world OJ market, these hypotheses are validated.

Methodology

This paper analyzes the aforementioned threat in the context of a mathematical programming model of the world orange juice market (McClain 1989; Spreen et al. 2003a). Partial budgeting analysis is first used to estimate cultural care and tree replacement costs. Yield effects on cost per hectare (ha), per box, and per pound solids (PS) are then estimated, and a spatial equilibrium model of the world OJ market is adapted to estimate the market impacts of smaller crops due to reduced tree numbers and yields caused by CVC.

Partial Budgeting

Amidst other diseases such as leprosis, blight, citrus canker, sudden death, etc., CVC poses a serious challenge to the Sao Paulo citrus industry by negatively impacting

production and transaction costs (Williamson 1996). Not necessarily in order of importance, adverse impacts related to the following are expected. Firstly, implementation of the control program for new plantings and caretaking of new and adult groves (more inputs, pruning, spraying, eradication, replanting, resetting) will be costly, but all that should, in the long term, offset the conspicuous losses in the event of keeping the traditional system of citrus production as if CVC not existed. Secondly, to the extent that the prices of young trees grown in screen houses are high and orange prices are competitive, a black market for young trees grown in clandestine nurseries may continue to exist, requiring relatively costly enforcement. Thirdly, although young trees grown in protected greenhouses are meant to reduce risk, exposure to CVC continues to be endemic representing a threat. Fourthly, there will be need for continuous training of personnel to execute scouting and pruning more selectively and skillfully. Fifthly, reductions in yields and shortening of the economic life expectancy of groves will still likely occur; and some degree of grower disappointment will arise with respect to unachieved results and smaller returns with the new measures of control.

As described elsewhere in this paper, young citrus trees with multiple flushes are most susceptible to CVC, and adult trees with CVC may become uneconomic due to severe losses in fruit weights and sizes.

One of the measures to reduce the risk of introducing CVC into a citrus grove is the regulation that began January 1, 2003 which imposes that all nursery trees are to be grown in screened shaded greenhouses. Such a provision will result in an increased cost of young trees to growers. According to industry sources in Brazil, a young tree produced in an enclosed greenhouse is roughly 50 percent more expensive than if it were

grown in an open field. An estimate of the cost of growing screened young trees is US$ 1.55 per unit (at an exchange rate of R$ 2.80, Brazilian real, per US$ 1.00). Assuming a stand of 400 trees per ha for a new grove in Sao Paulo, the total cost per ha would be US$ 620, which is US$ 220 per ha higher than the cost of the conventional system.

According to industry sources, the cost per ha to implement a new grove with and without measures to control CVC is US$ 1,458 and US$ 1,231, respectively, a differential of US$ 227 per ha. For a grove comprised of one-year-old trees, the maintenance cost per ha with and without measures of CVC control is US$ 367 and US$ 301, respectively, an additional of US$ 66 per ha. Furthermore, in a two-year-old grove, maintenance cost per ha with and without measures of CVC control is US$ 480 and US$ 402, respectively, a difference of US$ 78 per ha. Summing up these cost differentials over the first three years, CVC measures of control would add on average US$ 371 per ha to the cost of production.

Even with the proper use of control measures for CVC, there is an annual tree-death-loss rate of one percent. In Sao Paulo, a grove established in 1998 with protected young trees, adequately cared for by spraying against sharpshooters, still showed a level of CVC incidence of about 3.2 percent by the end of the third year. In contrast, a grove comprised of unscreened young trees planted in the same year, although under the same care, showed a CVC incidence of 23.5 percent across all trees (Citrograf 2003).

Production of protected young citrus trees is still unable to meet (at normal prices) the demand for new plantings and replantings. It is known that large growers are supplying themselves with young trees grown in their own protected nurseries and are ordering young trees from certified nurserymen, leaving behind small and medium

growers who also need to comply with the new regulation and are less likely to be able to afford the investment of growing their own protected young trees. At present, there is an estimated shortage of approximately 8.7 million young trees annually; nonetheless industry sources say that this deficit will be met within few years.

As stated by an industry source, the use of young trees grown in protected greenhouses makes the costs of living with CVC more tolerable. On average, a total of about US$ 456 per ha is spent on control measures in the first year, with scouting and pruning accounting for US$ 15, and spraying accounting for US$ 30. For the second, third and fourth years, the total annual cost is about US$ 450 per ha, with US$ 30 for scouting and pruning, and US$ 25 for spraying. Thus, through the end of the fourth year, the total cost per ha is approximately US$ 1,806, with US$ 105 for scouting and pruning, and US$ 105 for spraying. These costs are related to groves with 357 to 408 trees per ha.

CVC production losses can be large and may result in substantial losses in earnings; this result depends on the elasticity of demand and the effect that reduced production has on price; if demand is inelastic (elastic), CVC reduced production will result in a price that more than offsets (does not offset) the reduced production and earning will increase (decrease). Based upon a 2002 Fundecitrus survey, 38.28 percent of the 290 adult trees per ha (FAS, the Foreign Agricultural Service) had CVC symptoms. Another Fundecitrus survey indicates that on average CVC results in a 43.29 percent loss in per-tree production by weight *ceteris paribus*. Based on an average yield of 2.2 90-pound boxes of oranges per healthy tree (Muraro and Spreen 2003), the production lost in one ha with 38.28 percent of the trees having CVC would be about 106 boxes. In this paper, it is assumed that, in Sao Paulo, a 90-pound box of oranges has 6.0 PS, whether

the fruit is healthy normal or off-grade. Consequently, the production lost in one ha of adult trees would be equivalent to 636 PS. In this case, the CVC impacted grove would yield 532 boxes per ha or 3,192 PS per ha.

Based on an average per box on-tree price of US$ 2.50 for oranges in Sao Paulo over the last years, the total production loss per ha would be around US$ 265 (this result ignores average price effects). On a per box basis over the total reduced production, this is about US$ 0.50 per box (US$ 265 divided by 532 boxes), equivalent to approximately US$ 0.08 per PS (US$ 0.50 divided by 6 PS).

Muraro and Spreen (2003) estimated total production and other related costs in 2000-01 at US$ 0.2296 per PS, or US$ 1.38 per box. Based on a yield of 257 boxes per acre (one hectare equals 2.47 acres), the total production costs per ha were approximately US$ 875. On the other hand, with CVC, yield drops to 215.46 boxes per acre, or 532 boxes per ha or 3,192 PS per ha. Hence, for the same level of spending of US$ 875 per ha, the CVC yield effect on average would increase production cost to US$ 1.64 per box or US$ 0.2741 per PS, an increase of US$ 0.26 per box or US$ 0.0445 per PS, or 19 percent.

A Spatial Equilibrium Model of the World OJ Market

A model developed, updated and modified since 1989 (McClain 1989; Spreen et al. 2003a) at the University of Florida is used to analyze the impact of CVC in the world orange juice market. The model consists of four orange juice production areas (Sao Paulo, Florida, Mexico, and California) and four consumption regions (the United States, Canada, the European Union or the EU, and Japan).

Over the forecast horizon, Sao Paulo and Florida production levels are considered endogenous whereas Mexico and California production levels are assumed to be exogenous. Existing tree inventories in Sao Paulo and Florida are used to forecast orange production in each area. To predict orange juice production in each region, historical processed utilization rates and juice yields are combined with the orange production forecast. A spatial price equilibrium is established by equating world production with world demand. Lagged grower (on-tree) prices are used to predict future tree plantings. Historical tree loss rates are used to estimate the survival of trees from one year to the next. The tree inventory is updated in a forward recursive fashion over a specified time span from 1999-00 through 2019-20.

The pricing structure of the model includes the tariff regimes imposed by consumption regions. The tariffs are assumed to remain unchanged over the period analyzed. Region specific demand equations are estimated, assuming annual growth rates: 1 percent in the United States, 0.2 percent in the EU, 2.5 percent in Japan, and 0.5 percent in Canada.

The model allocates the available supply of orange juice originating from the four production regions, with special interest in Brazil for this study, across the four consumption regions in order to establish a spatial price equilibrium. It is also assumed that production is equal to consumption in each year.

Mathematical Representation of the Model

The world orange juice model utilized in this study is a multi-year quadratic programming spatial equilibrium model that determines the optimal allocation of orange

juice across product forms and spatially separated markets over the time horizon under consideration, from 1999-00 through 2019-20.

In the demand side of the model, which is not the focus of this study, there are four consumption regions considered: the United States, Canada, the EU, and Japan. In the EU and Japan, the main processed orange product consumed is FCOJ. In the United States and Canada, both FCOJ and not-from-concentrate (NFC) are consumed, the latter currently accounting for about 35 percent and 30 percent, respectively, of total orange juice consumption in each country. For further details about the inverse linear demand systems of these four regions, see Spreen et al. (2003a).

Additionally on the demand side of the model, tariffs imposed on imported orange juice are considered, but they are not objects of discussion in this study. The United States levies a higher per unit tariff on imports from Brazil than from Mexico, and the European Union and Japan adopt ad valorem (percentage) tariffs. For further details about the issue, refer to Spreen et al. (2003a).

On the supply side of the model, Florida and Sao Paulo orange productions are based on each region's inventory of bearing and non-bearing trees. A new planting function was developed in order to know how new planting amounts react to price changes. Because orange trees take at least three to four years in Florida and five to six years in Brazil to reach commercial production levels, there exists a lag between a price signal and production response and output, whether it is to expand or to reduce planted area.

In Spreen et al. (2003a), the specification in which new plantings react to current and lagged on-tree prices seems to provide the best prediction of new plantings, i.e.,

$NP_{t+1} = f(ON_t,\ ON_{t-1}, ..., ON_{t-k})$, where: NP_{t+1} is new plantings in $t+1$; ON_t is the on-tree (or grower) price in year t; and k is the number of years in the lag structure.

Separate planting relationships for early and midseason oranges and Valencias were estimated by Spreen et al. (2003a). Since the prime interest rate and the interest rate for long-term U.S. government securities, considered as proxies for alternative non-citrus investment opportunities and included as explanatory variables, were found to be statistically insignificant, planting levels were only related to expected on-tree price variables for oranges and grapefruit. Data on planting levels and on-tree prices were obtained from two publications by the Florida Agricultural Statistics Service (FASS). Annual data from 1965 through 1999 (35 observations) were studied.

A double log model was used to model tree planting levels, which can be written as

(1) $LNP_{vt} = \delta_{v0} + \delta_{v1}\, LON^*_{1,t+1} + \delta_{v2}\, LON^*_{2,t+1} + \delta_{v3}\, LON^*_{3,t+1}$,

where v stands for variety of citrus ($v=1$ for early and midseason oranges; $v=2$ for Valencia oranges, $v=3$ for grapefruit); t stands for time (year); LNP_{vt} is the log of the number of trees planted of variety v in period t; and LON^*_{vt} is the log of the expected on-tree price of variety v in period t.

An adaptive expectations specification was used to model prices. The log of the expected on-tree price for each variety of citrus in the upcoming period is specified as a weighted average of the log of the current (actual) on-tree price and the log of current expected on-tree price. The weight for the log of the current price is λ $(0<\lambda<1)$ and the weight for the log of the current expected price is $1-\lambda$. Formally, the expected price

variables can be written as $LON^*_{v,t+1} = \lambda\, LON_{vt} + (1\text{-}\lambda)\, LON^*_{vt}$ or, by recursively substituting for LON^*_{vt} in this equation:

(2) $\quad LON^*_{v,t+1} = \sum_{j=0\ to\ t-1} \lambda(1\text{-}\lambda)^j\, LON_{v,t-j} + (1\text{-}\lambda)^t\, LON^*_{v1}\,, \qquad v=1, ..., 3\,,$

where LON_{vt} is the log of the on-tree price of citrus variety v in year t; and LON^*_{v1} is the log of the expected price for the first sample observation (1965). In other words, the log of the expected price $LON^*_{v,t+1}$ is composed of the log of the expected price at the beginning of the sample LON^*_{v1} times the factor $(1\text{-}\lambda)^t$, which decreases geometrically with time, and a sum of weighted prices $\sum_{j=0\ to\ t-1} \lambda(1\text{-}\lambda)^j\, LON_{v,t-j}$, in which the weights $\lambda(1\text{-}\lambda)^j$ decline geometrically over time. The weight λ was selected so as to minimize the sum of squared errors.

Substituting expression (2) into equation (1) results in

(3) $\quad LNP_{vt} = \delta_{v0} + \sum_{k=1\ to\ 3} \delta_{vk} \left(\sum_{j=0\ to\ t-1} \lambda(1\text{-}\lambda)^j\, LON_{k,t-j}\right) + \delta_{v4}\,(1\text{-}\lambda)^t\,,$

where $\delta_{v4} = \delta_{v1}\, LON^*_{11} + \delta_{v2}\, LON^*_{21} + \delta_{v3}\, LON^*_{31}$.

Inasmuch as preliminary analysis revealed a multicollinearity problem between the price variables for early and midseason oranges, Valencia oranges and grapefruit, where the simple correlation coefficients between the expected price variables defined by $\sum_{j=0\ to\ t-1} \lambda(1\text{-}\lambda)^j\, LON_{v,t-j}$ ranged from .91 to .99, only the own-price variables were included in the model (3). A grid search revealed that the best values for λ were .37 for early and midseason oranges and .26 for Valencia oranges. All the parameter estimates are significantly different than zero at the $\alpha = 10$ percent level. At the end of the sampling ($t=35$), the term $\delta_4(1\text{-}\lambda)^t$ approaches zero and can be ignored for predicting future expected prices.

In Sao Paulo citrus has competed with sugarcane for land and capital, the new planting equation for Sao Paulo is expressed by:

(4) $NP_{t+1}^{SP} = \eta_{SP} + \theta_{SP}\left[\frac{ON_t^{SP}}{SC_t}\right]$, where the superscript *SP* refers to Sao Paulo and SC_t is the price of sugarcane paid to growers in year *t*.

To input the supply side of the model, Florida data on the number of orange trees broken down by variety, age, and location were collected. Similarly, Sao Paulo data were estimated in terms of tree number distribution across age categories from data published by the FAS of the United States Department of Agriculture (USDA).

Letting n_{ia} be the number of trees in age category *a* in region *i*, where *i* can be Florida or Sao Paulo, and letting Y_{ia} be the yield of oranges in 90-pound boxes per tree associated with a tree of age *a* located in production region *i*, then the total fresh orange production in region *i* in 90-pound boxes is given by:

(5) $\sum_a n_{ia} Y_{ia} = TP_i$

So far the model has two main components: the production sub-models for Sao Paulo and Florida, and the pricing model. The production model for year *t* uses the price equilibrium from year $t - 1$ to compute on-tree prices in Sao Paulo and Florida. These prices are used in equations (3) and (4) to predict new plantings in each region. Trees of age $a - 1$ in year $t - 1$ are moved to age *a* in year *t*, adjusted for death loss, as shown by:

(6) $n_{ia,t} = n_{i,\,a-1,\,t-1}\,(1 - DL_{i,\,a-1})$,

where $DL_{i,\,a-1}$ is the death loss associated with trees of age $a - 1$ in region *i*. Therefore, plugging (6) in (5):

(7) $\sum n_{i,\,a-1,\,t-1}\,(1 - DL_{i,\,a-1})\,Y_{ia} = TP_i$

Another assumption in this spatial equilibrium model of the world OJ market is that processed orange utilization, given by U_i, is a fixed proportion of the crop. In Florida, processed orange utilization is higher than the one observed in Sao Paulo and both have remained relatively constant over the last years, at 94 percent and from 70-75 percent, respectively. Let OJ_i be orange juice production in region i and JU_i be a conversion factor between fresh oranges and the volume of orange juice, also known as juice yield, measured in PS per 90-pound box of fresh oranges. Therefore:

(8) $OJ_i = TP_i \ U_i \ JU_i$.

Since in the specification of the model Florida produces both NFC and FCOJ, to better convert and allocate fresh oranges into these two orange juice products, a separate sub-model is developed (i.e., a blending model for the U.S. market).

In this sub-model, orange attributes such as Brix, ratio, and color score are utilized to attain the juice quality. Ratio corresponds to the ratio Brix/acid, and color score is a 40-point scale in which darker juice is given a higher value.

Oranges at a Brix level above 12^o are given preference to produce NFC instead of FCOJ. The desired level of ratio in the U.S. market is between 15.5 and 17.5; therefore, the higher the ratio the sweeter the juice tastes. Juice from mid and late-season oranges such as Valencia, Natal and Pera Rio (the latter two only grown in Brazil) normally has higher color score than the one from early maturing varieties such as Hamlin, etc.

The aforementioned blending model assumes that FCOJ and NFC can be made from the following cultivars: Hamlins from Florida, Valencias from Florida, Valencias from California, Valencias from Mexico, and Valencias from Brazil, since Pera Rio, Valencia and Natal grown in Brazil are assumed to be identical for juice quality purposes.

According to Fundecitrus (Ayres and Massari 2003), the incidence of CVC in 2002, although not statistically different across varieties, was 41.52 percent (Pera Rio), 38.88 percent (Natal), 35.92 percent (Valencia) and 26.14 percent (Hamlin). Given that the distribution of varieties in Brazil is not publicly available and the model assumes Valencia as the Brazilian input to produce its orange juice, the incidence in Valencia may be considered a good proxy for the overall incidence of 38.28 percent found in the survey sample.

The quality requirements established in the blending sub-model are minimum and maximum Brix for NFC, minimum and maximum ratio and minimum color score for both FCOJ and NFC. Estimates of average Brix, ratio, and color score for each of the ingredients were provided by industry sources.

Thus, mathematically, the blending model is formulated letting Z_{ivp} be the pound solids of orange juice made from variety v from production region i used to make juice type p and a_{ivpc} be the level of quality attribute c per unit of Z_{ivp}, where: i = Florida, California, Mexico or Brazil, v = Hamlin or Valencia, p = FCOJ or NFC, and c = Brix, ratio or color.

The desired level of quality attribute c is achieved by imposing the following constraints:

(9) $\sum_{v} a_{ivpc} Z_{ivp} \leq QU_{ipc}$, where QU_{ipc} is the upper limit imposed on quality attribute c in product p produced in region i; and

(10) $\sum_{v} a_{ivpc} Z_{ivp} \geq QL_{ipc}$, where QL_{ipc} is the lower limit imposed on quality attribute c in product p produced in region i.

Once the new tree age distribution is known, equations (7) and (8) are used to project orange juice production in both regions. After $OJ_{iv,t}$ is calculated, it is used as input into the spatial equilibrium model. Omitting the time subscript for simplicity, the spatial model is as follows:

$$Max \quad \sum_{j=EU,Japan} \frac{1}{1+AD_j}\left(a_j Q_j - \frac{1}{2} b_j Q_j^2\right) \quad +$$

$$\sum_{j=US,Canada} \left[\begin{array}{l} \int\left(\alpha_{1j} - \beta_{1j} Q_{j,FCOJ} + \gamma_{1j} Q_{j,NFC}\right) d\, Q_{j,FCOJ} \\ + \int\left(\alpha_{2j} - \beta_{2j} Q_{j,NFC} + \gamma_{2j} Q_{j,FCOJ}\right) d\, Q_{j,NFC} \end{array} \right]$$

$$-\sum_i \sum_j \sum_p T_{ijp} X_{ijp}$$

$$s.t. \quad -\sum_i X_{ijp} + Q_{jp} \leq 0$$

$$-Y_{ip} + \sum_j X_{ijp} \leq 0$$

$$-\sum_v Z_{ivp} + Y_{ip} \leq 0$$

$$\sum_p Z_{ivp} \leq OJ_{iv}$$

$$\sum_v a_{ivpc} Z_{ivp} \leq QU_{ipc}$$

$$\sum_v a_{ivpc} Z_{ivp} \geq QL_{ipc}$$

all variables are non-negative, where

- AD_j is the ad valorem tariff imposed by region j (the EU or Japan), in percentage;
- Q_j is the quantity of FCOJ (including that purchased as FCOJ and chilled reconstituted juice from FCOJ) consumed by region j (the EU or Japan), in PS;

- $Q_{j,p}$ is the quantity of orange juice product p (FCOJ, including that purchased as FCOJ and chilled reconstituted juice from FCOJ, or NFC) consumed by region j (United States or Canada), in PS;
- T_{ijp} is the transfer cost of product p from production region i (California, Florida, Sao Paulo or Mexico) to region j (Canada, U.S., EU or Japan), which equals the sum of the product p's per unit transportation cost t_{ij} and per unit tariff imposed by region j (Canada or U.S.) tar_j, in US$ per PS;
- X_{ijp} is the quantity of orange juice product p shipped from supply country i to demand region j, in PS;
- Y_{ip} is product p produced in supply region i, in PS;
- OJ_{iv} is the quantity of orange juice produced in region i with variety v, in PS; and
- and all other variables are defined as before.

The two combined sub-models, production and spatial pricing, are solved in a forward recursive fashion over the specified time horizon spanning from 1999-00 to 2019-20. The program is written in GAMS (General Algebraic Modeling System) and it is used to solve the model on a PC (personal computer).

For the sake of interpretation of the model, there are some other important assumptions that are also considered, such as: individual years will not be taken into account for analysis purposes; psychological effects are not included in the model; prices are nominal; duty drawback issues are not considered; cross commodity competition is not considered either; and the model does not deal with exchange rates.

Analysis

Two scenarios are analyzed via a spatial equilibrium model on the impact of the actual existence and the hypothetical inexistence of CVC, focusing not only on the modeling but also on the issue and its results and implications.

As noted elsewhere, Sao Paulo data on the number of orange trees distributed across age categories were estimated from historic data published by the FAS on new plantings, non-bearing and bearing trees.

Table 3-1. Sao Paulo Orange Tree Inventory, By Age Category, 1999-00, in Million Trees.

Age	Actual With CVC	Estimated Without CVC
1	4	7.8
2	4	16.5
3	4	14.8
4	7	14.5
5	9	7.4
6	10	7.4
7	13	7.3
8	15	7.1
9	10	14.1
10	11	14.0
11	11	13.7
12	8	13.4
13	8	8.1
14	8	7.8
15	9	7.5
16	9	8.6
17	8	8.5
18	8	6.8
19	8	6.5
20	6	6.3
+20	4	20.5
Total	174	218.6
Bearing	162	179.5

Source: The actual tree numbers are from FAS. The estimated figures are simulated values from an earlier version of the model as shown in Table 3-2.

Table 3-2. Estimated Sao Paulo Orange Tree Inventory, By Age Category, 1995-96 through 1999-00, in Million Trees.

Age	95-96	Survival Rate 95-96	96-97	97-98	98-99	99-00
1	7.5	1.000	14.5	14.8	16.5	7.8
2	7.5	1.000	7.5	14.5	14.8	6.5
3	7.5	1.000	7.5	7.5	14.5	14.8
4	7.5	0.990	7.5	7.5	7.5	14.5
5	15.0	0.990	7.4	7.4	7.4	7.4
6	15.0	0.990	14.9	7.4	7.4	7.4
7	15.0	0.980	14.9	14.7	7.3	7.3
8	15.0	0.980	14.7	14.6	14.4	7.1
9	9.3	0.980	14.7	14.4	14.3	14.1
10	9.3	0.970	9.1	14.4	14.1	14.0
11	9.3	0.960	9.0	8.8	14.0	13.7
12	11.0	0.950	8.9	8.7	8.5	13.4
13	11.0	0.945	10.5	8.5	8.2	8.1
14	9.0	0.940	10.4	9.9	8.0	7.8
15	9.0	0.930	8.5	9.8	9.3	7.5
16	9.0	0.930	8.4	7.9	9.1	8.6
17	8.0	0.930	8.4	7.8	7.3	8.5
18	8.0	0.900	7.4	7.8	7.2	6.8
19	8.0	0.900	7.2	6.7	7.0	6.5
20	6.0	0.850	7.2	6.5	6.0	6.3
+20	6.0	0.850	10.2	14.8	18.1	20.5
Total	202.9		208.6	214.1	220.8	218.6

Source: FAS.

The disaggregated and total 1999-00 tree inventory is different for the model with CVC than the one considered without CVC (Table 3-1). In the model with CVC, the 1990-00 FAS tree inventory estimated for each age category has been adopted. Meanwhile, in the without CVC scenario, the 1999-00 tree inventory has been estimated based upon the 1995-96 FAS data estimated for each age category and updated up to 1999-00 season utilizing the 1995-96 estimated survival rate (Table 3-2). The 1995-96 season is assumed to be the turning point from which CVC significantly started to reduce non-bearing tree population in Sao Paulo *ceteris paribus* (given that the death rate due to

other pests and diseases remains unchanged). Such downward trend can be noticed in Figures 3-4 and 3-5.

A comparison of the results between the two models, with and without CVC, brings interesting evidence in compliance with economic theory. It is important to point out that all estimates in the model are calculated taking into account normal weather conditions for all production regions, not considering droughts, freezes, hail, floods or any other deviating climatic phenomena from the average. Thus, the model can be considered a useful tool to help observe and interpret the behavioral trend of the citrus industry over time, assuming long-term average production per tree.

Table 3-3. Estimated Orange Production in Brazil, 2001-02 through 2019-20, in Million 90-Pound Boxes.

Season	With CVC	Without CVC	Difference
2001-02	330.0	391.3	-61.3
2002-03	337.4	391.9	-54.4
2003-04	333.9	391.7	-57.8
2004-05	332.7	392.6	-59.9
2005-06	333.7	396.6	-62.8
2006-07	337.6	401.8	-64.2
2007-08	342.6	408.6	-66.0
2008-09	349.9	414.8	-64.9
2009-10	359.8	419.8	-60.0
2010-11	372.1	425.3	-53.2
2011-12	386.9	431.6	-44.7
2012-13	402.0	439.8	-37.8
2013-14	415.8	447.0	-31.2
2014-15	429.6	453.9	-24.3
2015-16	442.5	459.7	-17.3
2016-17	455.0	465.2	-10.1
2017-18	466.6	470.8	- 4.3
2018-19	476.1	475.8	0.3
2019-20	484.3	480.9	3.4

The first simulation year of the model is for the 1999-00 crop year and continues in a forward recursive manner up until the 2019-20 season. Actual 1999-00, 2000-01, and 2001-02 Sao Paulo orange crops were factored into the with CVC scenario.

Consider estimated orange production in Brazil from 2001-02 through 2019-20 (Table 3-3). Interestingly enough, the model with CVC predicts for the first ten years of the 21^{st} century a reduction of about 30 million bearing trees in Sao Paulo when compared to the without CVC model (Table 3-4). If 15.2 million new trees were not planted annually over the first two decades of the 21^{st} century, the production gap between the two models would be wider. According to Fundecitrus (2003), in 2001, the annual installed production capacity for young trees was about 2.1 million units and in 2002, 3.7 million units (of which 50 percent are grafted on Citrumelo Swingle and 20 percent, on Rangpur Lime), but industry sources say that the deficit should be made up rapidly. At this growth rate, the required annual production of 15.2 million trees should be matched by 2005 to maintain the bearing tree inventory. The level of 15.2 million trees annually may no longer be necessary as the population recovers from losses due to CVC. When replants are all disease free and planted, and the level of CVC control in the field is stable, a new loss rate is expected to prevail and be near the one of healthy trees *ceteris paribus*. According to the model, such scenario should be witnessed by the end of the second decade of the 21^{st} century.

As expected from theory, a scenario with CVC (i.e., fewer bearing trees) would imply lower production as compared to a scenario without CVC. Without CVC *ceteris paribus*, Sao Paulo would have produced about 60 million boxes more annually over the first decade of the 21^{st} century. Given the perennial nature of citrus, the production gap

between the with CVC and without CVC scenarios narrows only throughout the second half of the time horizon under study, as a lag response to price incentives in which the new plantings made during the first half start to lead to larger and larger crops afterwards. A full recovery of the production with CVC is estimated to take place in season 2018-19 as long as the new trees all come from screened greenhouses. From 2000-01 until 2018-19, cumulative losses due to CVC average 45 million boxes annually.

Table 3-4. Estimated Orange Bearing Tree Inventory in Sao Paulo, 2001-02 through 2019-20, in Million Trees.

Season	With CVC	Without CVC	Difference
2001-02	153.8	190.0	-36.2
2002-03	149.0	187.0	-38.0
2003-04	153.5	189.5	-36.0
2004-05	158.0	191.2	-33.3
2005-06	163.6	194.2	-30.6
2006-07	169.0	196.9	-27.9
2007-08	174.2	199.7	-25.5
2008-09	179.6	202.5	-22.9
2009-10	185.0	205.2	-20.2
2010-11	190.4	207.8	-17.4
2011-12	195.8	210.5	-14.7
2012-13	200.9	213.2	-12.3
2013-14	205.8	216.1	-10.3
2014-15	210.5	219.0	- 8.5
2015-16	215.0	221.9	- 6.9
2016-17	219.3	224.4	- 5.1
2017-18	223.5	226.8	- 3.3
2018-19	227.3	229.0	- 1.7
2019-20	230.9	231.3	- 0.4

One inference that could be drawn from the Fundecitrus survey in conjunction with the results of the model is that, in 2002, 38.28 percent of around 159 million bearing trees grown in Sao Paulo (nearly 60.9 million trees) produced in weight only 56.71 percent of what they would produce if it were not CVC. Considering an average yield of 2.4 90-pound boxes of normal oranges per healthy tree, the production lost in the 60.9

million trees due only to CVC would then be approximately 63.3 million boxes, a figure quite close to the annual average estimated by the model of 60 million boxes for the first decade of the 21st century.

Based upon Fundecitrus survey showing an increasing CVC incidence on bearing trees, it can be inferred from the with CVC model's predicted tree inventory for the period under study that the resulting lower orange crops are in accordance with what is observed in actuality: over the first years of the 2000s, it is observed a flat continuous pattern of crop size due to an increasing severity rate of the symptoms among trees older than six years of age. More recently, the rate of new plantings associated with the lag response in production, so usual in perennial crops like orange, simply have not been able to overpass such losses. Nevertheless, with the new regulation requiring young trees be grown only in screened nurseries, it is expected that the incidence as well as the severity of the disease will be reduced over time, leading to healthier and more resistant trees and consequent smaller and smaller production losses. This will only happen if all or the majority of growers practice all possible in field methods to suppress CVC.

Since orange juice production in Sao Paulo follows the same trend as its orange fruit production, where processed utilization is assumed to be fixed in the model (i.e., 75 percent of the crop), similar reasoning applies to the analysis of the orange juice production gap in which Sao Paulo would be producing about 250 million PS more in OJ annually over the first decade of the 21st century if it were not because of CVC *ceteris paribus*. Likewise orange production, the recovery of OJ production with CVC is estimated to start in the early 2010s and to equal projected production without CVC within season 2018-19 (Table 3-5).

Table 3-5. Estimated FCOJ Production in Brazil, 2001-02 through 2019-20, in Million PS.

Season	With CVC	Without CVC	Difference
2001-02	1,465.2	1,737.6	-272.4
2002-03	1,498.2	1,739.8	-241.7
2003-04	1,482.4	1,739.0	-256.6
2004-05	1,477.3	1,743.3	-266.0
2005-06	1,481.8	1,760.7	-278.9
2006-07	1,498.7	1,783.8	-285.1
2007-08	1,521.1	1,814.2	-293.1
2008-09	1,553.4	1,841.7	-288.4
2009-10	1,597.4	1,864.0	-266.6
2010-11	1,652.1	1,888.3	-236.2
2011-12	1,717.9	1,916.1	-198.3
2012-13	1,784.9	1,952.8	-167.9
2013-14	1,846.0	1,984.5	-138.4
2014-15	1,907.4	2,015.4	-108.0
2015-16	1,964.5	2,041.2	- 76.7
2016-17	2,020.4	2,065.3	- 44.9
2017-18	2,071.6	2,090.5	- 18.9
2018-19	2,114.1	2,112.6	1.5
2019-20	2,150.2	2,135.2	15.0

With respect to on-tree price, without CVC, Sao Paulo orange on-tree price would have been around US$ 0.60 per box lower annually in the first decade of the 21st century (Table 3-6). With respect to FOB (Free On Board) OJ price, the price estimated for the without CVC scenario is about US$ 0.10 per PS lower annually when compared to the with CVC model during the first ten years of the 21st century (Table 3-7). By the end of the second decade of the 2000s, on-tree and OJ prices are estimated to be equal in both models.

Intuitively, and the model estimates show that, the Florida citrus industry is better off with the existence of CVC in Sao Paulo. In a without CVC scenario, on-tree prices for Florida growers would be approximately US$ 0.52 per box lower annually over the

first ten years of the 21st century. On OJ FOB prices, the estimated annual impact is around US$ 0.09 per PS less over the same period.

Table 3-6. Estimated Orange On-Tree Price in Brazil, 2001-02 through 2019-20, in US$/Box.

Season	With CVC	Without CVC	Difference
2001-02	2.07	1.40	0.67
2002-03	1.88	1.29	0.59
2003-04	1.99	1.37	0.61
2004-05	2.07	1.45	0.62
2005-06	2.14	1.51	0.63
2006-07	2.18	1.55	0.63
2007-08	2.20	1.56	0.64
2008-09	2.20	1.60	0.60
2009-10	2.17	1.64	0.53
2010-11	2.11	1.69	0.42
2011-12	2.06	1.74	0.32
2012-13	2.00	1.76	0.23
2013-14	1.96	1.80	0.15
2014-15	1.92	1.85	0.07
2015-16	1.90	1.90	-0.01
2016-17	1.88	1.97	-0.09
2017-18	1.87	2.02	-0.15
2018-19	1.89	2.09	-0.20
2019-20	1.92	2.15	-0.23

The model estimates that, with the recovery from CVC in Sao Paulo *ceteris paribus*, Florida is expected to end up with about 33,000 more acres of orange groves by the end of 2020 than if CVC had not existed in Brazil. The model also predicts increasing US OJ imports from Brazil over the second decade of the 2000s when prices begin to drop as Brazil recovers from CVC. Therefore, Brazil is expected to shift part of its growing European exports to the U.S. in the second decade of the 21st century.

CVC has caused Brazil to lose to the U.S. some of its share on the world OJ market, mostly Europe. Throughout the CVC recovery in Sao Paulo *ceteris paribus*, the U.S. is expected to replace most of the estimated annual 120 million PS OJ deficit that

Brazil is estimated to stop shipping to Europe due to CVC over the first two decades of the 21st century.

Table 3-7. Estimated Brazilian FCOJ FOB Price, 2001-02 through 2019-20, in US$/PS.

Season	With CVC	Without CVC	Difference
2001-02	0.73	0.62	0.12
2002-03	0.70	0.60	0.11
2003-04	0.72	0.61	0.11
2004-05	0.73	0.62	0.11
2005-06	0.75	0.63	0.11
2006-07	0.75	0.64	0.11
2007-08	0.76	0.64	0.11
2008-09	0.76	0.65	0.11
2009-10	0.75	0.66	0.09
2010-11	0.74	0.67	0.07
2011-12	0.73	0.67	0.06
2012-13	0.72	0.68	0.04
2013-14	0.71	0.69	0.03
2014-15	0.71	0.69	0.01
2015-16	0.70	0.70	0.00
2016-17	0.70	0.71	-0.02
2017-18	0.70	0.72	-0.03
2018-19	0.70	0.74	-0.03
2019-20	0.71	0.75	-0.04

Results and Implications

Both the partial budgeting (to estimate cultural care, tree replacement cost and yield effect on cost per ha, per box, and per PS) and the modified spatial equilibrium model of the world OJ market (to estimate the market impacts of smaller crops due to reduced tree numbers caused by CVC) clearly show that CVC does and will exert a major impact on the size and profitability of the Sao Paulo citrus industry.

The model's estimates suggest an average annual loss of 60 million boxes during the first decade of the 21st century, or 45 million boxes a year over the first two decades, representing an estimated lost revenue of US$ 126 million annually at the farm level (for

a box at US$ 2.10, the annual average price level estimated by the model to occur with CVC during the first decade of 2000 *ceteris paribus*). On the other hand, considering the price levels of the without CVC scenario for the same period, the total annual lost revenue at the farm level due to CVC would be approximately US$ 90 million.

Table 3-8. Annual Estimated Economic Impact of CVC, First Decade of the 21st Century.

Factor	Million US$
orange production loss of 60 million boxes	90.0 – 126.0
CVC yield effect on mature groves	88.4
young trees at US$ 1.55 each	23.6
implementation of new groves	15.2
scouting and pruning in new groves	1.0
spraying in new groves	1.0
scouting, pruning and spraying in mature groves	66.8
Total	286.0 – 322.0

At the processing level, an annual loss of about 250 million PS in OJ production over the first decade of the 21st century represents an estimated lost revenue of US$ 182.5 million annually (for an average FOB OJ price at US$ 0.73 per PS).

At the nursery level, with the new regulation imposing production and commercialization of young trees only in screened greenhouses, the total annual cost to build and run such an infrastructure is estimated at US$ 15.2 million to produce a total needed demand for 15.2 million young trees a year.

With regard to resetting and replanting, at the grove level, the grower will spend US$ 1.55 per young tree when he/she needs to plant a new grove or just replace an unproductive tree. Given a total annual demand for 15.2 million young trees, the estimated cost of purchasing young trees is nearby US$ 23.6 million a year.

In order to annually plant new groves with 15.2 million young trees produced in screened greenhouses, assuming a stand of 400 trees per ha, totaling 38 thousand ha, up

to the end of the fourth year growers are expected to spend about US$ 1,806 per ha, of which US$ 105 are for scouting and pruning, and US$ 105 are for spraying. Thus, the total estimated annual cost to plant new groves is around US$ 17.2 million, of which US$ 1 million for scouting and pruning, and US$ 1 million for spraying against CVC sharpshooters.

Now considering that growers spend nearly US$ 503 per ha annually to maintain a mature grove. Such a grove is one that has not been planted with protected young trees (i.e., there is no much hope that this grove will last long). Of the US$ 503 per ha, US$ 5.83 are spent on scouting and pruning, and US$ 13.81 are spent on spraying. Applying those figures to an estimated total of 3.4 million ha of mature groves to be scouted, pruned, and sprayed against sharpshooters, that would represent an additional annual cost of approximately US$ 66.8 million.

As a result of the CVC yield effect, elsewhere in this paper an additional cost of production of US$ 0.26 per box or US$ 0.0445 per PS is estimated. For an annual projected crop (with CVC) of 340 million boxes for the first decade of the 21st century, such additional cost represents an impact of US$ 88.4 million annually.

The number of growers, mostly small ones, who cannot fully or partly afford to adopt such CVC measures and bear the CVC yield effect is hard to estimate. Nevertheless, in total, CVC represents an estimated annual economic impact, at least for the first decade of the 21st century, of US$ 286 million to US$ 322 million to the Sao Paulo citrus industry.

Concluding Remarks

This paper analyzed the CVC threat to the Brazilian citrus industry in the context of a mathematical programming model of the world orange juice market developed at the University of Florida (McClain 1989; Spreen et al. 2003a). Two scenarios were studied via a spatial equilibrium model on the impact of existent and nonexistent CVC incidence, along with a partial budgeting for each scenario.

As far as the economic impact of CVC on Brazilian citrus is concerned, an estimated annual economic impact, at least for the first decade of the 21st century, is US$ 286 million to US$ 322 million. A few other but important conclusions can be stated: the expected result of the analysis is likely reduced trade in orange juice between Brazil and its consumer markets as CVC grows; the main result of the analysis is that CVC has resulted in reduced production of Brazilian OJ; CVC resulted in approximately 60 million boxes of lost production; as a result, world OJ prices are higher; this will benefit growers in Florida; and Brazil will recover thanks to the new technological path implemented and production should approach 400 million boxes by 2009-10, *ceteris paribus*. It is possible that such result could not be achieved due to the "Sudden Death" citrus disease, which is having a greater impact than CVC. Round orange trees grafted on Rangpur Lime are totally susceptible to the disease and the disease is moving at about 30 km per year.

CHAPTER 4
DUTY DRAWBACK AND
THE U.S. ORANGE JUICE EXPORT DEMAND

Introduction

Although the United States is a net importer of orange juice (OJ), a notable amount for blending, the U.S. also exports OJ, some of which is eligible for duty drawback. Duty drawback is a refund of duties (e.g., tariffs) or internal revenue taxes. The U.S. Government has offered drawback provisions to foster the export of various U.S. agricultural commodities since the Tariff Act of 1789 (Hill 1893). The intention of drawback is to encourage U.S. commerce and manufacturing.

Most U.S. imports of OJ are subject to a tariff, which is a fixed amount per unit of product (excise tax). For 2003, the most favored nation (MFN) tariff rates for frozen concentrated orange juice (FCOJ) and not-from-concentrate orange juice (NFC) are US$ 0.2972 per single strength equivalent (SSE) gallon and US$ 0.1704/SSE gallon, respectively (Tables 4-1 and 4-2). The MFN tariff rates have declined by 15 percent since 1994 according to the General Agreement on Trade and Tariffs (GATT). No further tariff rate declines are scheduled, but with the trend towards trade liberalization at the World Trade Organization (Doha Round), including special trade agreements between blocks of countries, uncertainty exists with regard to what future tariff rates may be. As a matter of fact, much concern on the part of the Florida citrus industry has been expressed towards the establishment of the Free Trade Area of the Americas (FTAA) for 2005, mainly because the tariffs that apply to Brazil will likely have to be phased out in

order for the U.S. to have Brazil aboard the FTAA. Brazil is not only the largest Latin-American consumer market for U.S. products and services but also is the largest producer of OJ in the world and is the dominant supplier of imported OJ to the U.S. market (Table 4-3).

Table 4-1. Tariff Rate Quota Schedule for Imported Frozen OJ to U.S.

	NAFTA					
	Mexico				CBERA	MFN
Year	In-Quota[a]	Over-Quota[b]	Snapback[c]	Canada	Caribbean	Brazil
	US$/SSE gallon					
1989	n/a	n/a	n/a	0.3143	free	0.3502
1990	n/a	n/a	n/a	0.2802	free	0.3502
1991	n/a	n/a	n/a	0.2423	free	0.3502
1992	n/a	n/a	n/a	0.2083	free	0.3502
1993	n/a	n/a	n/a	0.1742	free	0.3502
1994	0.1751	0.3415	0.3502	0.1401	free	0.3502
1995	0.1751	0.3327	0.3415	0.1022	free	0.3415
1996	0.1751	0.3240	0.3324	0.0682	free	0.3324
1997	0.1751	0.3152	0.3237	0.0341	free	0.3237
1998	0.1751	0.3065	0.3150	free	free	0.3150
1999	0.1751	0.2977	0.3059	free	free	0.3059
2000	0.1751	0.2977	0.2972	free	free	0.2972
2001	0.1751	0.2977	0.2972	free	free	0.2972
2002	0.1751	0.2977	0.2972	free	free	0.2972
2003	0.1751	0.2977	0.2972	free	free	0.2972
2004	0.1751	0.2382	0.2972	free	free	0.2972
2005	0.1751	0.1786	0.2972	free	free	0.2972
2006	0.1191	0.1191	0.2972	free	free	0.2972
2007	0.0595	0.0595	0.2972	free	free	0.2972
2008	free	free	0.2972	free	free	0.2972

[a] Tariff applied to first 40 million SSE gallons of FCOJ imports from Mexico.

[b] Tariff applied to imports from Mexico exceeding 40 million SSE gallons of FCOJ up to 70 million SSE gallons from 1994 through 2002, and up to 90 million SSE gallons from 2003 through 2008.

[c] Tariff applied to imports from Mexico exceeding 70 million SSE gallons from 1994 through 2002 and to imports from Mexico exceeding 90 million SSE gallons from 2003 through 2008 if a price trigger is also eclipsed (a price-based safeguard will provide for the reimposition of higher MFN tariffs if FCOJ daily average prices for 5 consecutive days fall below the previous 5-year average for that month.

Source: NAFTA, Office of the U.S. Trade Representative.

Table 4-2. Tariff Rate Quota Schedule for Imported Not From Concentrated OJ to U.S.

	NAFTA				
	Mexico			CBERA	MFN
Year	In-Quota[a]	Over-Quota[b]	Canada	Caribbean	Brazil
	US$/SSE gallon				
1989	n/a	n/a	0.1780	free	0.2007
1990	n/a	n/a	0.1590	free	0.2007
1991	n/a	n/a	0.1401	free	0.2007
1992	n/a	n/a	0.1174	free	0.2007
1993	n/a	n/a	0.0984	free	0.2007
1994	0.1003	0.1872	0.0795	free	0.2007
1995	0.1003	0.1739	0.0568	free	0.1969
1996	0.1003	0.1605	0.0379	free	0.1893
1997	0.1003	0.1472	0.0189	free	0.1855
1998	0.1003	0.1338	free	free	0.1817
1999	0.1003	0.1204	free	free	0.1742
2000	0.1003	0.1070	free	free	0.1704
2001	0.0936	0.0936	free	free	0.1704
2002	0.0803	0.0803	free	free	0.1704
2003	0.0669	0.0669	free	free	0.1704
2004	0.0535	0.0535	free	free	0.1704
2005	0.0401	0.0401	free	free	0.1704
2006	0.0268	0.0268	free	free	0.1704
2007	0.0134	0.0134	free	free	0.1704
2008	free	free	free	free	0.1704

[a] Tariff applied to first 4 million SSE gallons of SSOJ imports from Mexico.
[b] Tariff applied to imports from Mexico exceeding 4 million SSE gallons of SSOJ.
Source: NAFTA, Office of the U.S. Trade Representative.

Brazil, a MFN, has "a cost advantage in delivering bulk FCOJ to both the U.S. and the European markets" (Muraro and Spreen 2003, p.3). Drawback has enabled the U.S. to cover such cost differentials and compete in some export markets. If the duty drawback subsidy is removed under the current tariff rates, U.S. exports would be expected to decrease, since Florida OJ producers would no longer have the negative tax that they need to foster their exports.

U.S. OJ imports from Caribbean countries (CBERA, Caribbean Basin Economic Recovery Act), Andean Trade Preference Act countries, Israel, Canada, and South Africa, are duty free. OJ imports from Mexico receive preferential treatment as established by

the North American Free Trade Agreement (NAFTA), i.e., the first 40 million SSE gallons of FCOJ and all NFC from Mexico are subject to reduced tariff rates; presently, imports of FCOJ above the 40 million gallon level are subject to a tariff rate that is about the same as the MFN tariff; the NAFTA tariffs on FCOJ and NFC are scheduled to decline to zero by 2008.

Table 4-3. U.S. Imports of OJ, 1985-2003.

Year	Mexico	Brazil	CBERA	Total
	- - - - - - - - - - Mil. SSE Gallons - - - - - - - - - -			
1985	9.17	562.45	6.95	581.71
1986	32.47	527.91	8.92	574.29
1987	40.96	470.83	8.69	522.87
1988	52.38	352.84	5.45	413.28
1989	45.16	332.15	7.51	388.82
1990	63.27	390.80	13.82	472.11
1991	49.35	269.89	5.52	326.83
1992	6.59	249.70	18.68	276.88
1993	20.94	309.67	16.45	348.59
1994	45.88	321.72	17.39	387.80
1995	68.71	96.49	21.46	188.60
1996	49.70	201.71	28.50	281.51
1997	50.94	155.88	45.91	254.01
1998	67.79	188.74	40.61	299.05
1999	48.62	270.80	32.23	354.83
2000	43.49	207.51	65.68	320.54
2001	37.49	156.71	45.09	242.23
2002	37.12	117.96	31.51	191.37

Source: U.S. Department of Commerce.

Knowing how much U.S. OJ exports are affected by changes in duty drawback, which is tied to the MFN tariff schedule[1], helps better understand the relevance of duty drawback as a strategic marketing policy mechanism to foster U.S. OJ exports. Since there are no time series data on the available duty drawback credits that were actually claimed by U.S. OJ exporters, nor are there observations on U.S. OJ exports in a scenario without duty drawback provision, this paper intends to provide estimates of the impact of

duty drawback on the U.S. OJ export demand indirectly via a single equation econometric model in which exports in SSE gallons are regressed against the following relevant explanatory variables: time trend, U.S. OJ price, Rotterdam OJ price, European exchange rate, and quarterly dummies to remove seasonality.

In the context of the model, Florida and Brazil are considered the major suppliers of OJ to the world market, and domestic and foreign produced OJ are viewed as similar but different products, varying by color, viscosity and sugar/acid ratio, among other attributes. As such, OJ products by these two countries of origin are considered to be close but not perfect substitutes.

In the next section, a description of the duty drawback situation with summary data as well as some theoretical considerations are provided. U.S. OJ export demand and allocation of OJ by origin across markets are graphically analyzed. A series of graphs show the theoretical impact of U.S. OJ duty drawback. Following, the problem statement and hypothesis with respect to the effect of duty drawback on U.S. OJ export demand are provided. The fourth section describes the methods utilized, including the data set, the econometric model and the simulation analysis. In the fifth section, a presentation and discussion of the empirical results is provided. Finally, the last section offers some concluding remarks.

Duty Drawback and Some Theoretical Considerations

Duty on an imported product subsequently exported or used to produce a product for export increases the production cost of the exported product, putting the exporter at a competitive disadvantage in foreign markets. To enable U.S. industry to compete more effectively in foreign markets, the U.S. Government offers drawback on duties collected

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[1] Duty drawback can also be claimed on only "under quota" Mexican OJ imports.

on the imported good eventually exported in some form (U.S. Customs Service 2002). Drawback is provided for numerous products, including components used in manufacturing aircraft, automobiles, computers, apparel, footwear, and petroleum, as well as OJ. With the U.S. being a major importer and exporter of OJ, drawback is an important provision for selling OJ in foreign markets. Without drawback, duties paid on OJ imports subsequently exported can put sellers at a critical cost disadvantage in export markets.

Drawback law allows one to export a substitute product in lieu of imported product; that is, drawback is allowed even though it is the substitute product, not the imported product, that is exported. Substitution drawback provisions apply, but are not unique, to OJ. The definition of substitute product under drawback law depends on whether the exported product was manufactured or not. When the substitute is used in manufacturing export product, the import must also be used in manufacturing. For manufactured OJ products (blends or packaged products), drawback law requires that the import and substitute be the same grade; if the imports are USDA Grade A, then the substituted product exported must be USDA Grade A. This requirement allows a moderate degree of flexibility in substitution. For example, the minimum score for USDA Grade A product is 90 points[2], so that, Grade A imports with 90 score and Grade A exports with 95 score, or vice versa, would meet the substitution requirements.

When an OJ import or its substitute is not used in manufacturing (i.e., unused merchandise), the substitute product exported must be commercially interchangeable with the imported product. The definition of commercially interchangeable is based on New

[2] The Grade A score of 90 is for color, defects and flavor; in addition, Grade A product must also satisfy standards for other factors, including ratio, Brix and recoverable oil.

York Cotton Exchange standards for FCOJ futures contracts; e.g., if the imports are Grade A with 93 score, then the substitute must be Grade A with 93 score or close enough to be considered commercially interchangeable. Under these standards, substitution for unused merchandise drawback is defined more narrowly than for manufacturing drawback. As a result of this narrower definition, unused merchandise drawback opportunities are more limited compared to those for manufacturing drawback. Substitution for manufacturing drawback is more lenient than for unused merchandise drawback, since manufacturing drawback is expected to create more U.S. jobs than unused merchandise drawback.

For both manufacturing and unused merchandise, drawback is 99 percent of the duty with the other 1 percent used for defraying Customs costs. The Government allows up to three years after importation for drawback to be claimed.

Theoretical Impact of U.S. OJ Duty Drawback

Consider the world demands for OJ by origin, and, for simplicity, assume two origins, the U.S. and Brazil (BR), since they are responsible for over 85 per cent of total OJ production in the world (FAO 2003). The world demand for each origin is an aggregate of demands across markets, the U.S. and the rest of the world (ROW). Graphically, these demands can be shown in the charts below, which are not intended to be in precise scale. Figure 4-1 is a rough approximation of the interrelationships of the world OJ market. Competitive behavior is assumed.

US/US and US/ROW charts show the demand for U.S. OJ in the U.S. and in the ROW, respectively. BR/US and BR/ROW charts show the demand for Brazilian OJ in the U.S. and in the ROW, respectively. In the short run, the supply from regions US

(S_{US}) and BR (S_{BR}) is assumed to be constant. The model is also based on the assumptions that the delivered-in price for OJ in the U.S. is the same whether it is sold in the U.S. or the ROW, the delivered-in price for OJ in Brazil is similarly the same regardless the market in which it is sold.

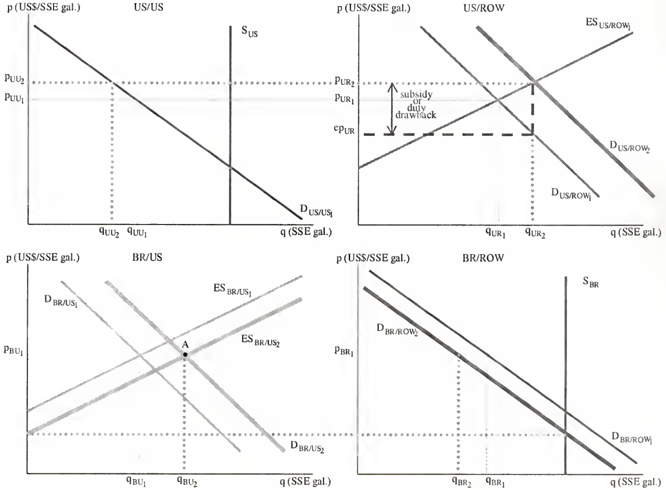

Figure 4-1. Short-Run World OJ Supply and Demand Conditions.

Chart US/ROW illustrates the with- and without-duty drawback excess supply and demand conditions for U.S. OJ in the ROW. Initially, without duty drawback (subsidy or negative excise tax), the equilibrium price and quantity are p_{UR1} and q_{UR1}.

With duty drawback, the after-subsidy[3] demand for U.S. OJ in the ROW shifts upward (e.g., Nicholson 1972) by 99 percent of US$ 0.2972/SSE gallon for FCOJ and US$ 0.1704/SSE gallon for NFC, from $D_{US/ROW1}$ to $D_{US/ROW2}$, and the new price received by U.S. OJ exporters increases to p_{UR2}, and the new price paid by the ROW importers for U.S. OJ decreases to ep_{UR}. The vertical distance between p_{UR2} and ep_{UR} corresponds to the duty drawback or subsidy that the Government pays the exporter; in actuality, only 99 percent of duty can be refunded with the remaining one per cent for defraying Customs costs.

Duty drawback results in a higher U.S. net export price (e.g., from p_{UR1} to p_{UR2}) and a higher U.S. domestic price of the same amount, which shifts upward the demand for BR OJ in the U.S. from $D_{BR/US1}$ to $D_{BR/US2}$. The lower price for imported U.S. OJ in the ROW (ep_{UR}) reduces the quantity of BR OJ demanded in the ROW by shifting the demand for BR OJ in the ROW downward, from $D_{BR/ROW1}$ to $D_{BR/ROW2}$. As a result, the excess supply of BR OJ for the U.S. shifts rightward, from $ES_{BR/US1}$ to $ES_{BR/US2}$.

Chart BR/US shows the new equibrium price for BR OJ at point A, which remains the same as p_{BU1}, but with a higher demand q_{BU2} and a lower demand q_{BR2}. Note that price does not change for Brazil OJ in either the U.S. or ROW, although Brazil shifts product from the ROW to the U.S. (i.e., this is a price neutral case for Brazil). However, the BR OJ price may possibly increase or decrease with respect to p_{BU1}, depending on the strength of demand and excess supply shifts. For example, with a stronger (weaker) demand shift for Brazil OJ in the U.S., the Brazil price could possibly increase (decrease)

[3] The after-subsidy demand curve indicates the price paid by consumers plus the subsidy for a given quantity sold in the ROW. The location of the consumer demand curves in the graphs are determined by factors such as income, other prices and consumer preferences and are unchanged in the analysis. Instead

and, in turn, impact the demands for U.S. OJ in both the U.S. and the ROW. The markets shown in the graphs would interact in this fashion until a new equilibrium is reached.

Problem Statement and Hypothesis

The U.S. OJ duty drawback provision has been little investigated. With the prospect of the U.S. having to reduce the MFN OJ tariff schedule either because of the FTAA or the Doha Round, and, consequently, having to face smaller and smaller OJ duty drawback credits in the horizon, understanding the impact that duty drawback may have on U.S. OJ exports becomes more relevant.

A question that emerges is what would happen to U.S. OJ exports if duty drawback were completely or partly reduced under current tariff rates. This paper hypothesizes that OJ duty drawback is important to foster U.S. OJ exports and the lack of drawback may hinder U.S. OJ exporting efforts at current U.S. OJ production costs.

Methods

In order to address the problem of this paper, an econometric model of ROW export demand for U.S. OJ is estimated and simulated, focusing on the impact of duty drawback on U.S. OJ exports.

The model analyzed is comprised of a single equation for U.S. OJ exports. Based on demand theory, U.S. export and world prices for OJ are expected to be important factors underlying ROW demand for U.S. OJ and are included as explanatory variables in the model (Varian 1992; Mas-Collel et al. 1995). The U.S. export price used in this study is the FOB price at the U.S. port of origin. The Rotterdam price is used as proxy for the ROW OJ price. Prices in the model were assumed to be exogenous with OJ inventories

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of analyzing duty drawback by shifting the after-subsidy demand curve, one could work with the unchanged consumer demand and shift the excess supply curve down by the amount of the subsidy.

over the study period being sufficient, in general, for buyers to purchase as much as desired at offered prices.

In addition to prices, income in the ROW may be an important variable, reflecting foreign consumers' ability to pay. Since ROW disposable income levels in major export markets (Europe, Canada and Japan) generally trended upward over the study period, and, hence, including these separate market incomes in the model would result in a multicollinearity problem, a time trend is used as a proxy for income. This trend variable is also expected to capture other effects including inflation and population growth in world markets.

Since both the U.S. and ROW OJ prices are expressed in dollars, exchange rates are expected to have significant impacts on export demand. For a buyer of U.S. OJ in a foreign market, the relevant prices are the U.S. and ROW dollar prices times the exchange rate for that foreign market (foreign currency per dollar). Other U.S., non-OJ exports to that foreign market are also expected to be impacted by the exchange rate. That is, the exchange rate in question impacts not only the prices of OJ under consideration but also the prices of other imports competing for foreign consumer spending. To generally account for the impact of exchange rates on consumer budget decisions, these potential demand factors were initially considered as separate explanatory variables in the model. There was, however, a high degree of correlation between the European exchange rates and, arbitrarily, only that for France (Francs per U.S. dollar) was kept. Exchange rates for Canada and Japan were insignificant in preliminary analysis and excluded from the model.

Since quarterly time series data were used to estimate the model, three quarterly dummies were included as explanatory variables to remove seasonality.

Since there are no data on claimed OJ duty drawback credits, it is not possible to consider total available drawback credits as an explanatory variable. The amount of available credit may, however, impact the price at which some credits (owned by importers) are sold to exporters and hence the net subsidy obtained.

The demand model for U.S. OJ exports to the ROW is expressed as a linear function[4] of the time trend, the U.S. OJ export price paid by importers, the Rotterdam (E.U., the European Union) OJ price, the French Franc exchange rate, and the dummies for the first, second and third quarters. Formally, this demand model, under the current tariff rates, can be written as

(1) $qe1 = \beta_0 + \beta_1{*}T + \beta_2{*}pe1 + \beta_3{*}pe2 + \beta_4{*}FRF + \beta_5{*}Q1 + \beta_6{*}Q2 + \beta_7{*}Q3 + \varepsilon$,

where qe1 is the total volume of U.S. OJ exported (FCOJ and NFC)[5] in SSE gallons (U.S. Department of Commerce); T is the time trend (ranging from 1 through 56); pe1 is the U.S. OJ export price in US$/SSE gallon (U.S. Department of Commerce); pe2 is the Rotterdam (E.U.) OJ price in US$/SSE gallon (Food News); FRF is the exchange rate in French Francs/US$ 1.00 (IMF, International Monetary Fund); Q1 is the dummy for the first quarter; Q2 is the dummy for the second quarter; Q3 is the dummy for the third quarter; and ε is the error term.

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[4] Quadratic and double-log functional forms were also considered, but did not fit the data as well as the linear specification as measured by the coefficient of determination (for the log model, the R^2 was determined in terms of levels for comparison).

[5] A reliable breakdown of total OJ exports between FCOJ and NFC is not available.

The parameters for β_0 , β_5 , β_6 , and β_7 ,indicate the intercepts for the quarters (first quarter: $\beta_0 + \beta_5$; second quarter: $\beta_0 + \beta_6$; third quarter: $\beta_0 + \beta_7$; and fourth quarter: β_0).

The prices at other levels in the marketing chain differ from pe1 and pe2 by transportation, tariff/drawback and mark-up margins, which are embedded in the intercepts.

The coefficient β_1 is the trend effect, whose sign is expected to be positive (based on income growth), i.e., $\partial qe1/\partial T > 0$, meaning that export demand increases through time, *ceteris paribus.*

The coefficient β_2 indicates the slope for the U.S. export price pe1. This coefficient's sign is expected to be negative (based on the law of demand), i.e., $\partial qe1/\partial pe1 < 0$, meaning that the higher the U.S. OJ export price paid by importers (which could arise due to lowering duty drawback), the lower the export demand for U.S. OJ, *ceteris paribus.*

The coefficient β_3 indicates the slope for the ROW price pe2. Its sign is expected to be positive (given OJ products from the U.S. versus Brazil and other origins are substitutes), i.e., $\partial qe1/\partial pe2 > 0$, meaning that the higher the E.U. Rotterdam price paid by importers (mostly OJ coming from Brazil), the higher the export demand for U.S. OJ, *ceteris paribus.*

The coefficient β_4 indicates, the FRF slope which is expected to be negative, i.e., $\partial qe1/\partial FRF < 0$, that is, the more French Francs needed to buy one US dollar, the more expensive the U.S. OJ export and, therefore, the lower the export demand for U.S. OJ, *ceteris paribus.*

The error ε was initially assumed to be normally distributed, with mean 0 and covariance matrix $\sigma^2\mathbf{I}$, where **I** is an nxn identity matrix with n being the number of observations analyzed. In preliminary analysis, however, it was found that the errors followed a second order autocorrelation pattern, and the final model estimated was corrected for this degree of autocorrelation. Quarterly time series data comprised of 56 observations, ranging from the first quarter of 1989 through the fourth quarter of 2002, were studied. World preferences for OJ have been evolving over time. Before World War II, OJ was a single strength product. After the war, FCOJ was introduced and demand for this product grew rapidly. In the last two decades, NFC demand has experienced strong growth in the U.S. market; in the world market, the growth in NFC demand has largely occurred in the last decade. Although FCOJ is still the major product sold in export markets over the time period studied, significant demand for NFC exists. This situation likely bears on the demand estimates found in this study and is important in simulating the model to determine the impact of drawback as will be subsequently addressed.

The parameter estimation method for the standard linear model was used. The SAS statistical software package was employed to run the regressions. Initially the model was estimated by OLS (ordinary least squares). Then SAS's autoreg procedure was used to correct for second-order autocorrelation.

Simulation Assumptions

Duty drawback is an export driving factor whose effects cannot be separately estimated in the model. However, given duty drawback is embedded in the U.S. OJ export price in the model, an estimate of its impact on U.S. OJ exports can be made.

Following some definitions are provided that are subsequently used to isolate the effect of duty drawback. Definitions:

- p = net price (US$/SSE gallon) received by the exporter including subsidy from duty drawback
- t = tariff (US$/SSE gallon) = US$ 0.2972/SSE gallon for FCOJ
- $s = 0.99 * t * 0.77$ = actual subsidy (US$/SSE gallon) from duty drawback = US$ 0.2266/SSE gallon[6]
- pe1 = p-s = U.S. OJ export market price paid by the importer in US$/SSE gallon

Given these definitions, U.S. export demand equation (1) can be written as

(2) $qe1 = a + \beta_2(p\text{-}s)$,

where a is an intercept which includes the effects of seasonality (quarter), time, the ROW price, and exchange rates.

To solve for the impact of duty drawback on U.S. OJ exports, first totally differentiate the equation (2), that is,

$dqe1 = \partial qe1/\partial pe1 * \partial pe1/\partial s * ds$

or

$dqe1 = - \beta_2 * ds$, where p is assumed to be constant, i.e., $\partial p/\partial s = 0$, an assumption to be addressed later.

Given we expect $\beta_2 < 0$, if $ds > 0$, then $dqe > 0$, or if $ds < 0$, then $dqe < 0$.

[6] Most U.S. OJ imports are FCOJ; to date relatively little NFC has been imported. That is, most duty drawback credits are for FCOJ. On the other hand, according to the Florida Citrus Processors Association, in volume, Florida OJ exports were 77 percent FCOJ and 23 percent NFC in 2001-02. Given that Florida accounted for 85 percent of U.S. OJ exports in 2001-02, it is assumed that 77 percent of U.S. OJ exports are FCOJ. Since FCOJ imports cannot be used for NFC manufacturing nor are these two OJ forms considered commercially interchangeable under the current provision, virtually all NFC exports are not eligible for drawback credits. Hence, the actual amount of claimable credit would correspond only to 99 percent of the total available subsidy originated from each unit of FCOJ exported, i.e., 0.99 * US$ 0.2972 * 77% = US$ 0.2266).

Empirical Results

The OLS estimates for the standard linear model are shown in Table 4-4. These results indicate the presence of positive first-order serial correlation. Hence, the model was initially re-estimated correcting for this problem. Application of the test for higher degrees of autocorrelation was inconclusive. Therefore, the model was further corrected for second order autocorrelation. With that, the parameters become efficient and no evidence of higher degrees of autocorrelation was found.

Table 4-4. Ordinary Least-Squares and Autoregressive Parameter Estimates for U.S. OJ Exports to the ROW, in Million SSE Gallons.

Variable	Coefficient	OLS	First-Order	Second-Order
Constant	β_0 (t value)	96.022 (9.09)	96.605 (8.37)	95.270 (8.46)
T	β_1 (t value)	0.593 (11.03)	0.584 (8.64)	0.600 (10.44)
pe1	β_2 (t value)	-24.714 (-9.15)	-26.424 (-9.60)	-24.009 (-8.46)
pe2	β_3 (t value)	0.296 (0.11)	0.981 (0.30)	0.140 (0.05)
FRF	β_4 (t value)	-5.981 (-5.32)	-5.511 (-3.99)	-6.147 (-5.13)
Q1	β_5 (t value)	3.496 (1.94)	2.893 (1.88)	3.705 (2.26)
Q2	β_6 (t value)	7.978 (4.39)	7.424 (4.39)	8.457 (4.16)
Q3	β_7 (t value)	2.754 (1.51)	2.268 (1.45)	3.123 (1.89)
Total R-Square		0.8264	0.8469	0.8585
$d_L = 1.31$ $d_U = 1.86$ n = 56 k' = 7		Evidence of positive autocorrelation	Zone of indecision	Evidence of neither positive nor negative autocorrelation
Durbin-Watson (at 0.05 significance level)		$1.304 < d_L$	$d_U > 1.6806 > d_L$	$1.9730 > d_U$

All parameter estimates were significantly different than zero at or near the 95 percent level, except that for the Rotterdam price. U.S. export demand appears to be strongest and weakest in the second and fourth quarters, respectively. The positive time trend parameter estimate indicates an upward trend in the demand for U.S. OJ exports as expected. Also, as expected, the negative parameter estimate for the French Franc exchange rate indicates that as this currency appreciates (depreciates) the demand for OJ exports increases (decreases). Surprisingly, the Rotterdam price had an insignificant

impact, suggesting no cross-price effects between U.S. and Brazilian OJ in the E.U., perhaps because the U.S. is a residual exporter of OJ.

The parameter estimate for the U.S. OJ export price was negative as expected and again significant. This result is the basis for the subsequent simulations.

In order to gauge the impact on U.S. OJ export demand due to changes in the amount of subsidy (duty drawback), the table below summarizes some simulations as to how many SSE gallons might no longer be exported should the subsidy be reduced under the assumption that the price received by U.S. exporters remains unchanged at p_{UR2} in gragh US/ROW. For a reduction of US$ 0.01 in the subsidy, it is expected that the U.S. will export approximately 240.1 thousand SSE gallons less per quarter. Estimated decreases in exports for larger subsidy reductions at US$ 0.05 intervals up to the limit of US$ 0.2266 are also shown in Table 4-5. The intent of this table is to give an idea what might happen to U.S. OJ exports as the duty drawback subsidy is phased out gradually.

Table 4-5. Simulation of U.S. OJ Export Demand with Duty Drawback Phase-Out, Quarterly, in Million SSE Gallons.

Previous s	ds	New s	dqe1 (Million SSE Gallons)
US$ 0.2266	US$ 0.0000	US$ 0.2266	0.000
US$ 0.2266	- US$ 0.0100	US$ 0.2166	- 0.240
US$ 0.2266	- US$ 0.0500	US$ 0.1766	- 1.200
US$ 0.2266	- US$ 0.1000	US$ 0.1266	- 2.401
US$ 0.2266	- US$ 0.1500	US$ 0.0766	- 3.601
US$ 0.2266	- US$ 0.2000	US$ 0.0266	- 4,802
US$ 0.2266	- US$ 0.2266	US$ 0.0000	- 5.440

Note: s is the duty drawback subsidy; ds is the change in s; dqe1 is the change in the demand for U.S OJ in the ROW as a result of reduction in s.

These results imply that the export demand for U.S. OJ will be reduced by 5.4 million SSE gallons quarterly or 21.8 million SSE gallons annually if duty drawback no

longer exists, *ceteris paribus*, which corresponds to 18 percent of the annual average U.S. OJ export level from 1989 through 2002.

As noted in qualifying the above analysis, the price received by U.S. exporters has been assumed to remain unchanged. This result is approached as the U.S. excess supply to the ROW or equivalently the U.S. demand curve for U.S. OJ becomes perfectly elastic. This solution, however, is not a general one. Depending on the strengths of the own and cross-price elasticities, the price received for U.S. OJ would likely decrease with removal of the duty drawback subsidy. When the price decreases, U.S. OJ exports would still be expected to decrease without drawback but the decline in exports will not be as great as under the previous assumption of constant price. The estimated 21.8 million SSE gallons annual decrease for the constant price assumption can be viewed as the worst case scenario in terms of volume lost, to the extent price declines for other likely cases.

Concluding Remarks

The duty drawback regime helps transfer the duty collected by the U.S. Government to the citrus industry in such a way as to provide an incentive to develop new markets in the world.

Both pictorically and numerically in this paper, the importance of the duty drawback provision for U.S. OJ export demand has been shown. Duty drawback was chiefly created to lower the cost of importing OJ that itself or a subsitute is then exported. According to the econometric model of this paper, *ceteris paribus*, if duty drawback were eliminated under current tariff rates, in the worst case, the U.S. would export about 21.8 million SSE gallons annually less, approximately 18 percent of total U.S. OJ exports on

average. The U.S. price of OJ would also likely decline without the duty drawback subsidy.

It is beyond the scope of this study to estimate the demands for Brazil and U.S. OJ separately in the different markets (Europe, Canada and other). Given the quality of the present data, such an endeavor should be pursued in future studies.

If in the future data on credits were to become available, the possibility that amount of available credits impacts the effective sudsidy, through the price at which credits are sold, would be an interesting issue for futher research.

Since the U.S. is a net exporter of NFC and a net importer of FCOJ, the implications of changing the current drawback law in order to allow substitution of NFC for FCOJ imports need further investigation. Such a change may lead to a substantial increase in NFC exports, i.e., a shift in demand for U.S. NFC in the ROW (Brown 1998), given the MFN tariff schedule is not phased out during the trade liberalization process of the coming years.

Another area of interest would be the study of the market for drawback credits. Since the exporters are the ones who pay the tariff and, in turn, hold the credits, they may either sell the credits on the market or claim them through their own exports, particularly those Sao Paulo-based orange processors who purchased plant facilities in Florida and are able to produce both U.S. and Brazil OJ. It would also be interesting to study this market under different scenarios, such as the one where the proposed FCOJ/NFC substitution provision is introduced in the drawback law, allowing interchangeability, accompanied or not by the gradual phase-out of the MFN tariff schedule.

CHAPTER 5
SUMMARY AND CONCLUSIONS

This dissertation addressed three issues important to the world processed orange industry and, for each issue, a different methodological approach was used.

The first paper (chapter 2) is related to governance structures in order to answer why all Sao Paulo orange processors own grove operations to partly supply their plants whereas virtually all Florida processors do not. The second issue refers to the impact of a supply shock to the Brazilian citrus industry (chapter 3). This paper is an assessment of the economic impact of a non-curable disease that affects over one-third of the Brazilian citrus trees, the world's largest producer followed by the United States. The third paper relates to the issue of duty drawback (chapter 4). Duty drawback is a device used by the U.S. Government to encourage exports. In this paper, an econometric analysis is presented to measure the impact of possible elimination of the duty drawback provision.

From the two cases analyzed in chapter 2, it can be argued that the different governance structures that have evolved in the processed orange industries in Florida and Sao Paulo are the result of the different institutional environments that exist in the United States and Brazil. Theories of the New Institutional Economics were used to conduct a comparative analysis. It is argued that differences in payment systems, investment costs in citrus groves, harvest labor costs, and target markets are the main explanatory factors in the different evolution paths found in Florida and Sao Paulo.

The level of backward vertical integration (BVI) in the Florida orange processed industry in 2001-02 is much lower than the one found in 1989-90 because there is low freeze risk in the citrus growing area, the costs of labor on farm are very high, the capital required to own a grove operation to supply a 10 million processing plant is prohibitive, water usage regulations are extremely stringent, and Florida processors' investment risk aversion is assumed to be high.

Interestingly, the increasing importance of not-from-concentrate (NFC) in the U.S. market apparently is not in compliance with the role that asset specificity plays in transaction costs economics. The fact that in 2001 NFC accounts for 40 percent of U.S. OJ consumption is not sufficient to make processors backward vertically integrate into owning grove operations. Further investigation is needed to learn more about the networking intricacies among processors that produce NFC, such as Tropicana (forward vertically integrated into distribution), Citrus World (partly backward and forward vertically integrated cooperative), Southern Gardens (partly backward vertically integrated and Tropicana's supplier), Cutrale (Minute Maid's supplier), and Citrosuco (Tropicana's supplier). The reason for this deviation from theory's prediction may rely upon four possibilities: for strategic purposes that NFC Florida processors are not backward vertically integrated; or the gains that would be obtained from BVI do not outweigh the aggregate effect of the other five listed variables; or these processors have a sufficient number of long-term contracts with growers and other processors that guarantees a steady supply of Valencia oranges to produce NFC.

In chapter 2, the governance structure of the orange processing industries of Florida and Sao Paulo was reviewed. In the beginning of the 21st century, the

institutional arrangements that have evolved in the two regions are quite different, though. The answer to an intriguing question as to whether BVI is a superior model compared to separate ownership of orange growing and processing in terms of economic efficiency is that the processing industry in Florida and Sao Paulo has optimally adapted to the institutional environment that exists in each region.

Chapter 3 analyzed the threat of citrus variegated chlorosis (CVC) to the Brazilian citrus industry in the context of a mathematical programming model of the world orange juice market developed at the University of Florida. Two scenarios were studied via a spatial equilibrium model on the impact of existent and nonexistent CVC incidence, along with a partial budgeting for each scenario.

The economic impact of CVC on Brazilian citrus was estimated to be ranging from US$ 286 million to US$ 322 million annually over the first decade of the 21st century. Other findings of the study were: likely reduced trade in OJ between Brazil and its consumer markets; CVC has resulted in reduced production of Brazilian OJ, approximately 60 million boxes equivalent of lost production annually; as a result, world OJ prices are higher, which has benefited growers in Florida; and, thanks to the new technological path implemented, Brazil is expected to recover from CVC by 2009-10, possibly approaching 400 million boxes by then, if the "Sudden Death" citrus disease and any other catastrophe does not prevail.

In chapter 4, it was found that the current U.S. OJ duty drawback regime has helped the Florida citrus industry in such a way as to provide an incentive to develop new markets in the world. The importance of the duty drawback provision for U.S. OJ export demand was shown both graphically and statistically. Duty drawback was chiefly created

to lower the cost of importing OJ so that the same product or a substitute is then exported. According to the econometric model estimated in chapter 4, if duty drawback were eliminated under the current tariff rates, in the worst case, the U.S. would export about 21.8 million SSE gallons annually less, approximately 18 percent of total U.S. OJ exports on average. The U.S. price of OJ would also likely decline without the duty drawback subsidy.

It was beyond the scope of the analysis in chapter 4 to estimate the demands for Brazil and Florida OJ separately in each of the major markets (Europe, Canada and the United States). Given the quality of the present data, such an endeavor was undoable and should be pursued in future studies. Also, if in the future data on quantity of duty drawback credits were to become available, the possibility that amount of available credits impacts the effective subsidy would be an interesting issue for further research.

The implications of changing the current drawback law in order to allow substitution of NFC for FCOJ imports need further investigation. Such a change may lead to a substantial increase in NFC exports (i.e., a shift in demand for U.S. NFC in the ROW, given the MFN tariff schedule is not phased out during the trade liberalization process of the coming years).

Another area of interest could be the study of the market for drawback credits. Since the exporters are the ones who pay the tariff and, in turn, hold the credits, they may either sell the credits on the market or claim them through their own exports, particularly those Sao Paulo-based orange processors who purchased plant facilities in Florida and are able to produce both U.S. and Brazil OJ. It would also be interesting to study this market under different scenarios, such as the one where the proposed FCOJ/NFC substitution

provision is introduced in the drawback law, allowing interchangeability, accompanied or not by the gradual phase-out of the MFN tariff schedule.

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BIOGRAPHICAL SKETCH

Waldir Barros Fernandes, Jr., married to Gisele, an English language and American literature faculty member at the Sao Paulo State University (Unesp) at Sao Jose do Rio Preto, was born in Sao Paulo, state of Sao Paulo, Brazil, on March 30, 1965. He holds a Bachelor of Science degree in Agronomic Engineering, awarded in January 1988, at Unesp at Jaboticabal. Before his graduation, he participated in a selection process among 120 candidates for six positions at Citrosuco Paulista S/A, the largest Brazilian orange juice exporter then. He was hired for the position in December 1987 and worked in the fruit procurement area until May 1995. In 1993, he applied to the Master of Science program in business administration at the University of Sao Paulo (USP) at Sao Paulo and was admitted. There were 450 candidates and 40 positions and he was one of the only two candidates selected for the agribusiness major. He started the program in 1994 while he was still working for Citrosuco. However, in order to graduate in time, he had to leave Citrosuco. In August 1998, he got his M.Sc. degree and then moved to the U.S. to pursue a Ph.D. with the Food and Resource Economics Department (FRED) at the University of Florida, under the supervision of Dr. Thomas H. Spreen.

While at the University of Florida, Waldir was a graduate research assistant with the Florida Department of Citrus, at Gainesville. He received seven awards, as follows: winner of the New York Board of Trade FCOJ futures price forecast contest; The Honor Society of Agriculture Gamma Sigma Delta; University of Florida Outstanding International Graduate Student; as president of the Gator Citrus Club,

Agricultural and Life Sciences College Council's 2001-2002 Club of the Year, Outstanding Club Activities in Fundraising, and Outstanding Club Activities Above the Local Level; and The Dean's Leadership Award for Excellence in Academics and Outstanding Achievement.

Waldir mentored two visiting Brazilian undergraduate and FRED graduate students, performed twelve different community services, nine professional services to the Food and Resource Economics Department and two to the Horticultural Sciences Department in Brazil, Canada and the U.S. He also participated in nine professional meetings and educational trips in the U.S., Italy, Mexico and Brazil. Waldir gave twelve presentations at professional meetings and other events in the U.S., Australia and Brazil. He also published 15 articles in journals, magazines, newspapers, and websites, both in the U.S. and Brazil.

In brief, Waldir has worked with horticultural sciences, business administration and agricultural economics since 1987 and his main area of expertise is citrus economics and business administration.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation of the degree of Doctor of Philosophy.

Thomas H Spreen

Thomas H. Spreen, Chair
Professor of Food and
Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation of the degree of Doctor of Philosophy.

Mark G. Brown

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Associate Professor of Food
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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation of the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the College of Agricultural and Life Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 2003

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